NATIONAL MARINE FISHERIES SERVICE
ENDANGERED SPECIES ACT SECTION 7
BIOLOGICAL OPINION

Title:	Biological Opinion on (1) United States Navy's Surveillance Towed Array Sensor System Low Frequency Active Sonar Routine Training and Testing Activities in the Western and Central North Pacific and Eastern Indian Oceans from August 2019 and continuing into the reasonably foreseeable future (2) National Oceanic and Atmospheric Administration's National Marine Fisheries Service, Office of Protected Resources, Permits and Conservation Division's Promulgation of Regulations and Issuance of a Letter of Authorization for the United States Navy to "Take" Marine Mammals Incidental to Surveillance Towed Array Sensor System Low Frequency Active Sonar routine training and testing activities in the Western and Central North Pacific and Eastern Indian Oceans from August 2019 to August 2026
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1 INTRODUCTION

The Endangered Species Act of 1973, as amended (ESA; 16 U.S.C. 1531 et seq.) establishes a national program for conserving threatened and endangered species of fish, wildlife, plants, and the habitat they depend on. Section 7(a)(2) of the ESA requires Federal agencies to insure that their actions are not likely to jeopardize the continued existence of endangered or threatened species or adversely modify or destroy their designated critical habitat. Federal agencies must do so in consultation with the National Marine Fisheries Service (NMFS) for threatened or endangered species (ESA-listed), or designated critical habitat that may be affected by the action that are under NMFS jurisdiction (50 C.F.R. §402.14(a)). If a Federal action agency determines that an action "may affect, but is not likely to adversely affect" endangered species, threatened species, or designated critical habitat and NMFS concur with that determination for species under NMFS jurisdiction, consultation concludes informally (50 C.F.R. §402.14(b)).

Section 7(b)(3) of the ESA requires that at the conclusion of consultation, NMFS provides an opinion stating whether the Federal agency's action is likely to jeopardize ESA-listed species or destroy or adversely modify designated critical habitat. If NMFS determines that the action is likely to jeopardize listed species or destroy or adversely modify critical habitat, NMFS provides a reasonable and prudent alternative that allows the action to proceed in compliance with section 7(a)(2) of the ESA. If an incidental take is expected, section 7(b)(4) requires NMFS to provide an incidental take statement that specifies the impact of any incidental taking and includes reasonable and prudent measures to minimize such impacts and terms and conditions to implement the reasonable and prudent measures.

The action agencies for this consultation were the United States (U.S.) Navy (Navy) and NMFS' Permits and Conservation Division (Permits Division). The Navy proposes to conduct Surveillance Towed Array Sensor System (SURTASS) Low Frequency Active (LFA) sonar activities and the Permits Division proposes to promulgate regulations pursuant to the Marine Mammal Protection Act (MMPA) of 1972, as amended (16 U.S.C. 1361 et seq.) for the Navy to "take" marine mammals incidental to SURTASS LFA activities. The regulations would allow for the issuance of a Letter of Authorization (LOA) that will authorize the Navy to "take" marine mammals incidental to its proposed action, pursuant to the requirements of the MMPA.

This formal consultation, biological opinion (opinion), and incidental take statement completed in accordance with section 7(a)(2) of the statute (16 U.S.C. 1536 (a)(2)), associated implementing regulations (50 C.F.R. §§401-16), and agency policy and guidance, was conducted by NMFS Office of Protected Resources Endangered Species Act Interagency Cooperation Division (hereafter referred to as "we").

This document represents the NMFS opinion on the effects of the proposed SURTASS LFA sonar actions and related MMPA regulations on endangered and threatened species and

designated critical habitat. A complete record of this consultation is on file at the NMFS Office of Protected Resources in Silver Spring, Maryland.

1.1 Background

The Navy proposes to conduct training and testing activities within the SURTASS LFA sonar study area (hereafter referred to as the "action area"; see section 3.6 of this opinion for a description of the action area) from August 13, 2019and continuing into the reasonably foreseeable future. Navy SURTASS LFA sonar activities have been ongoing for well over a decade and as described below, many of these activities have been considered in previous ESA section 7 consultations.

In 2002, NMFS' Endangered Species Division completed its first consultation on the Navy's proposed employment of the SURTASS LFA sonar system and NMFS' Permits, Conservation, and Education Division's proposal to authorize the "take" of marine mammals pursuant to the Navy's employment of the SURTASS LFA sonar system. From 2002 through 2016, inclusive, NMFS completed consultations (and a conference report in 2015 and 2016) on each annual LOA the Permits and Conservation Division issued to the Navy for annual SURTASS LFA sonar missions. This timespan also included consultations on new MMPA regulations governing SURTASS LFA sonar training and testing activities in 2002, 2007, and in 2012. Each of the consultations from 2002 through 2016 concluded that the proposed actions would not likely jeopardize any ESA-listed species or result in the destruction or adverse modification of any designated critical habitat under NMFS jurisdiction (NMFS 2002b; NMFS 2003; NMFS 2004; NMFS 2005; NMFS 2007a; NMFS 2008a; NMFS 2009; NMFS 2010a; NMFS 2011b; NMFS 2012b; NMFS 2013b; NMFS 2014; NMFS 2015d; NMFS 2016a). Thus, this consultation builds upon the earlier work NMFS has done on previous SURTASS LFA sonar training and testing activities and uses the evidence we collected, analyzed, and synthesized for those earlier opinions as its foundation.

As described above, section 7 consultation was initiated for three sequential five-year MMPA regulations and again annually for the issuance of associated LOAs. These consultations assessed SURTASS LFA sonar training, testing, and military operations. In each case, the consultation concluded that the SURTASS LFA sonar routine training, testing, and military operations and the issuance of MMPA regulations and associated LOAs were not likely to jeopardize the continued existence of any endangered or threatened species, species proposed for listing under the ESA, or result in the destruction or adverse modification of designated critical habitat. During each consultation, we reviewed annual monitoring reports from the Navy on their SURTASS LFA sonar training and testing activities and the implementation of mitigation and monitoring measures and incorporated new information to reach our conclusion.

On September 30, 2016, NMFS received a request for formal consultation under section 7 of the ESA for its SURTASS LFA sonar training and testing activities on up to four vessels in non-polar areas of the Atlantic, Pacific, and Indian Oceans, and Mediterranean Sea from August 2017

through August 2022. Similar to previous consultations, we received a request from NMFS' Permits and Conservation Division's promulgation of five-year regulations that would be valid from 2017 through 2022 under the MMPA. Subsequently, on April 20, 2017, NMFS received a request from the Navy for formal consultation for proposed routine training, testing, and military operations of SURTASS LFA sonar from August 15, 2017, to August 14, 2022, in 15 mission areas of the western and central North Pacific and Indian Oceans. Before ESA section 7 consultation was completed, on August 10, 2017, in consultation with the Secretary of Commerce and pursuant to Title 16, Section 1371(f) U.S.C., the Secretary of Defense determined that it was necessary for national defense to exempt all military readiness activities that use SURTASS LFA sonar from compliance with the requirements of the MMPA for two years from August 13, 2017 through August 12, 2019, or until such time when NMFS issues regulations and a LOA under Title 16, Section 1371, for military readiness activities associated with the use of SURTASS LFA sonar, whichever is earlier (see 2017 National Defense Exemption[NDE],(Navy 2017c)). Because of the NDE, NMFS' Permits Division rescinded its request for consultation on the proposed MMPA regulations. As a result, the only activity we consulted on in 2017 was the Navy's use of SURTASS LFA sonar training and testing activities on up to four vessels in non-polar areas of the Atlantic, Pacific, and Indian Oceans, and Mediterranean Sea from August 2017 through August 2022.

The Fiscal Year 2019 (FY19) National Defense Authorization Act (NDAA), signed on August 13, 2018, amended the MMPA to extend the maximum period over which NMFS could authorize incidental takings of marine mammals under section 101(a)(5)(A) from specified activities by the Department of Defense from five to seven years.

1.2 Consultation History

On March 29, 2019, we received a formal request for consultation from the Navy for its SURTASS LFA sonar routine training and testing activities in the western and central north Pacific and eastern Indian Oceans from 2019 and continuing into the reasonably foreseeable future.

Key communication with the Navy and NMFS' Permits and Conservation Division regarding this consultation is summarized as follows:

On June 25, 2018, we received a biological evaluation and request for consultation for the Navy's use of SURTASS LFA sonar training and testing activities that would occur from August 2019, through August 2024, in the western and central north Pacific and eastern Indian Oceans.

On July 26, 2018, we received a Draft Supplemental Environmental Impact Statement (DSEIS) for the Navy's use of SURTASS LFA sonar training and testing activities.

On August 8, 2018, we provided comments to the Navy on the June 25, 2018 biological evaluation and Draft Supplemental Environmental Impact Statement (DSEIS) for SURTASS LFA Activities.

On September 11, 2018, the Navy provided responses to NMFS' ESA Interagency Cooperation Division's August 8, 2018 comments on the biological evaluation.

On October 26, 2018, the Navy submitted an unclassified annual mission report to NMFS for its 2017 to 2018 SURTASS LFA sonar activities.

On November 13, 2018, the Navy sent NMFS' ESA Interagency Cooperation Division a revised copy of the biological evaluation to reflect seven years of activity because of changes made to the MMPA by the FY19 NDAA, extending the proposed SURTASS LFA sonar training and testing activities from August 2019 and continuing into the reasonably foreseeable future. In addition, the revised biological evaluation included updates to the Navy's mitigation/buffer zone (see sections 3.4.2)

On December 3, 2018, we provided additional comments to the Navy on the biological evaluation.

On December 14, 2018, the Navy provided NMFS with its responses to NMFS' comments submitted on December 3, 2018 along with a revised final copy of the biological evaluation.

On February 12, 2019, the Navy submitted updated information regarding Offshore Biological Important Areas (OBIAs) as a supplement to their biological evaluation (see section 3.4.8).

On March 27, 2019, we received a request from NMFS' Permits and Conservation Division for formal ESA section 7 consultation on their proposal to promulgate regulations and issue one seven-year LOA pursuant to the MMPA on the Navy's use of SURTASS LFA sonar during its 2019 to 2026 training and testing activities in the western and central north Pacific and eastern Indian Oceans.

As stated above, on March 29, 2019, we received a final request from the Navy to initiate formal consultation on SURTASS LFA sonar training and testing activities that would occur from August 13, 2019 and continuing into the reasonably foreseeable future, in the western and central north Pacific and eastern Indian Oceans.

On April 3, 2019, we initiated consultation with the specified agency on the following actions:

1. The Navy on its general SURTASS LFA sonar training and testing activities from August 13, 2019 and continuing into the reasonably foreseeable future, in the western and central north Pacific and eastern Indian Oceans.
2. NMFS Permits and Conservation Division on its proposal to promulgate seven-year MMPA regulations authorizing Navy takes of marine mammals protected under the MMPA.
3. NMFS Permits and Conservation Division on its proposal to issue a seven-year letter of authorization pursuant to the seven-year MMPA regulations on the Navy's SURTASS LFA sonar training and testing activities.

On June 17, 2019, the Navy requested a final review of its Final Supplemental Environmental Impact Statement (FSEIS) for SURTASS LFA sonar training and testing activities. The review ended on June 21, 2019. The FSEIS was published on July 5, 2019 (84 FR 32168).

We subsequently prepared this opinion and incidental take statement in accordance with section 7(b) of the ESA and implementing regulations at 50 CFR §402.

2 THE ASSESSMENT FRAMEWORK

Section 7(a)(2) of the ESA requires Federal agencies, in consultation with NMFS, to ensure that their actions are not likely to jeopardize the continued existence of endangered or threatened species; or adversely modify or destroy their designated critical habitat.

"Jeopardize the continued existence of" means to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of an ESA-listed species in the wild by reducing the reproduction, numbers, or distribution of that species." 50 C.F.R. §402.02.

"Destruction or adverse modification" means a direct or indirect alteration that appreciably diminishes the value of designated critical habitat for the conservation of an ESA-listed species. Such alterations may include, but are not limited to, those that alter the physical or biological features essential to the conservation of a species or that preclude or significantly delay development of such features (50 C.F.R. §402.02).

An ESA section 7 assessment follows a well-established pattern: understanding the proposed action, identifying stressors created by the action and what ESA-listed species and designated critical habitat may be affected by the proposed action, then assessing the effects of the action on those ESA-listed resources. Below we describe the process specific to this consultation and this opinion.

1) We describe the proposed action (Section 3.1) the action area (Section 3.6), and any interrelated or interdependent action (Section 3.7) related to the proposed action.

2) We deconstruct the action into the activities such that we can identify those aspects of the proposed action that are likely to create pathways for adverse impacts to ESA-listed species or designated critical habitat. These pathways or "stressors" may have direct or indirect effects on the physical, chemical, and biotic environment within the action area. We also consider the spatial and temporal extent of those stressors (Section 4 – Potential Stressors).

3) We identify the ESA-listed species and designated critical habitat that are likely to co-occur with those stressors in space and time (Sections 5 and 6), and describe the status of those species that are likely to be adversely affected (Section 6). During consultation, we determined that some ESA-listed species and critical habitat that occur in the action area are not likely to be adversely affected by the proposed action. For those "not likely to adversely affect" determinations, we summarize our findings, including detailed summaries explicitly

stating why all stressors associated with the proposed action are not likely to affect certain ESA listed species or critical habitat and do not carry those species or critical habitat forward in this opinion (Section 5). We describe the status of species that are likely to be adversely (Section 6).

4) We describe the environmental baseline in the action area (Section 7) including: past and present impacts of Federal, state, or private actions and other human activities in the action area; anticipated impacts of proposed Federal projects that have already undergone formal or early section 7 consultation, and impacts of state or private actions that are contemporaneous with the consultation in process.

5) We evaluate the direct and indirect effects of an action on ESA-listed species or designated critical habitat, together with the effects of other activities that are interrelated or interdependent with that action (Section 8).

    a) During our evaluation, we determined that some stressors were not likely to adversely affect some ESA-listed species, categories of ESA-listed species, or designated critical habitat; we summarize those findings in Section 8.1.

    b) The stressors that are likely to adversely affect ESA-listed species were carried forward for additional analysis (Section 8.1.1). For these stressors, we evaluate the available evidence to determine how individuals of those ESA-listed species are likely to respond given their probable exposure. This is our response analyses.

    c) We provide an assessment of the potential effects of stressors that are likely to affect ESA-listed species during the proposed activities (Sections 8.2 and 8.3).

    d) We evaluate the proposed action's mitigation to determine the effectiveness of the Navy's and NMFS' proposed mitigation measures and their impacts on the amount and type of exposures to stressors (Section 8.4)

    e) We identify (where possible) the number, age (or life stage), and gender of ESA-listed individuals that are likely to be exposed to the stressors and the populations or subpopulations to which those individuals belong. This is our exposure analysis for ESA-listed species (Section 8.5).

    f) We evaluate the available evidence to determine how individuals of those ESA-listed species are likely to respond given their probable exposure. This is our response analyses for ESA-listed species (Section 8.6).

    g) We assess the consequences of these responses of individuals that are likely to be exposed to the populations those individuals represent, and the species those populations comprise. This is our risk analysis for ESA-listed species (Section 8.7).

6) We describe any cumulative effects of the proposed action in the action area (Section 9).

7) We integrate and synthesize the above factors (Section 10) by considering the effects of the action to the environmental baseline and the cumulative effects to determine whether the action could reasonably be expected to:

   a) Reduce appreciably the likelihood of both survival and recovery of the ESA-listed species in the wild by reducing its numbers, reproduction, or distribution; or

   b) Reduce the conservation value of designated or proposed critical habitat.

8) We state our conclusions regarding jeopardy and the destruction or adverse modification of designated critical habitat (Section 11).

If, in completing the last step in the analysis, we determine that the action under consultation is likely to jeopardize the continued existence of ESA-listed species or destroy or adversely modify designated critical habitat, we must discuss the availability of reasonable and prudent alternatives that the agency and the applicant can take to avoid violation of section 7(a)(2). The reasonable and prudent alternative also must meet other regulatory requirements.

If incidental take of ESA-listed species is expected, section 7(b)(4) requires that we provide an ITS (Section 12 of this opinion) that specifies the amount or extent of take, the impact of the take, reasonable and prudent measures to minimize the impact of the take, and terms and conditions to implement the reasonable and prudent measures (ESA section 7 (b)(4); 50 C.F.R. §402.14(i); Section 12.4). ESA section (7)(o)(2) provides that compliance by the action agency with the terms and conditions exempts any incidental take from the prohibitions of take in ESA section 9(b) and regulations issued pursuant to ESA section 4(d).

"Take" is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by regulation as an act which actually kills or injures fish or wildlife and may include significant habitat modification or degradation which actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including, breeding, spawning, rearing, migrating, feeding or sheltering. NMFS has not defined "harass" under the ESA in regulation. On December 21, 2016, NMFS issued interim guidance on the term "harass," defining it as an action that "creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding, or sheltering" (NMFS 2016b). For purposes of this consultation, we relied on NMFS' interim definition of harassment to evaluate when the proposed activities are likely to harass ESA-listed species. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity.

We also provide discretionary conservation recommendations that may be implemented by action agency (Section 13). 50 C.F.R. §402.14(j). Finally, we identify the circumstances in which reinitiation of consultation is required. 50 C.F.R. §402.16 (Section 14).

2.1 Evidence Available for the Consultation

In 2002, NMFS' Endangered Species Division completed its first consultation on the Navy's proposed employment of the SURTASS LFA sonar system and NMFS' Permits, Conservation, and Education Division's proposal to authorize the "take" of marine mammals pursuant to the Navy's employment of the SURTASS LFA sonar system. From 2002 through 2016, inclusive, NMFS completed consultations (and a conference report in 2015 and 2016) on each annual LOA the Permits and Conservation Division issued to the Navy for annual SURTASS LFA sonar missions. This timespan also included consultations on MMPA regulations governing SURTASS LFA sonar training and testing activities in 2002, 2007, and in 2012. Additionally, NMFS completed a 2017 consultation and conference report on the Navy's 2017 NDE to conduct sonar training, testing, and military operations globally from 2017 to 2022. Thus, this consultation builds upon the earlier work NMFS has done on previous SURTASS LFA sonar training and testing activities and uses the evidence we collected, analyzed, and synthesized for those earlier opinions as its foundation.

For this consultation, we identified new lines of evidence on the potential effects of the SURTASS LFA sonar system on endangered species, threatened species, and designated critical habitat. We considered all lines of evidence available through published and unpublished sources that represent evidence of adverse consequences or the absence of such consequences. NMFS' status reviews for ESA-listed species also provide information on the status of the species including their resiliency, population trends, and specific threats to recovery, which contributes to our *Status of Endangered Species Act-Listed Resources*, *Environmental Baseline*, and *Effects of the Action* analyses.

To comply with our obligation to use the best scientific and commercial data available, we conducted electronic literature searches throughout the consultation, including within NMFS Office of Protected Resources' electronic library (using *Endnote* ® software). We examined the literature that was cited in the submittal documents and any articles we collected through our electronic searches. The Navy provided NMFS with a draft and final SEIS/SOEIS (Supplemental Environmental Impact Statement/Supplemental Overseas Environmental Impact Statement) on SURTASS LFA sonar routine training and testing activities that are proposed in the action area, along with a biological evaluation. We also evaluated the Navy's annual and comprehensive monitoring reports required by the previous five-year MMPA rule, LOA and previous opinions to assess the effectiveness of mitigation and actual take incidental to SURTASS LFA sonar operation levels where feasible. In addition, we engage regularly with the Navy to discuss new science and technical issues as part of the ongoing adaptive management program for the operation of SURTASS LFA sonar.

Considering the information that was available, this consultation and our opinion includes uncertainty about the basic hearing capabilities of some marine mammals, sea turtles, and fishes; how these taxa use sounds as environmental cues; how they perceive acoustic features of their environment; the importance of sound to the normal behavioral and social ecology of species; the mechanisms by which human-generated sounds affect the behavior and physiology (including the non-auditory physiology) of exposed individuals; and the circumstances that are likely to produce outcomes that have adverse consequences for individuals and populations of exposed species.

2.1.1 Approach to Assessing Effects to Marine Mammals

This section provides the Navy's approach to assessing the exposure and response of marine mammals to SURTASS LFA sonar. The Navy used the Acoustic Integration Model© (AIM) to simulate the sound field produced by the SURTASS LFA sonar source operations and determine the potential acoustic impacts to marine mammal species present within the sound field of the SURTASS LFA mission areas (also known as model areas) considered in this consultation.

Fifteen representative model areas in the western and central North Pacific and eastern Indian Oceans were analyzed to represent the acoustic regimes and marine mammal species that may be encountered during LFA sonar training and testing activities (See Table 1). To estimate the potential impacts to marine mammals in each of the model areas, a list of marine mammal stocks likely to be encountered in each region, by season, was developed, and abundance and density estimates were derived from the most current published literature and documentation available (See Table 4).

Table 1. Locations of the 15 Representative Model Areas for SURTASS LFA Sonar.

Model Area	*Model Area Name*	*Season*	*Notes*
1	East of Japan	38°N, 148°E	
2	North Philippine Sea	29°N, 136°E	
3	West Philippine Sea	22°N/124°E	
4	Offshore Guam	11°N, 145°E	Navy Mariana Islands Testing and Training Area
5	Sea of Japan	39°N, 132°E	
6	East China Sea	26°N, 125°E	
7	South China Sea	14°N, 114°E	
8	Offshore Japan 25° to	30°N, 165°E	
9	Offshore Japan 10° to	15°N, 165°E	

Model Area	***Model Area Name***	***Season***	***Notes***
10	Hawai‘i North	25°N, 158°W	Navy Hawai‘i-Southern California Testing and Training Area; Hawai‘i Range Complex
11	Hawai‘i South	19.5°N, 158.5°W	Navy Hawai‘i-Southern California Testing and Training Area; Hawai‘i Range Complex
12	Offshore Sri Lanka	5°N, 85°E	
13	Andaman Sea	7.5°N, 96°E	
14	Northwest of Australia	18°S, 110°E	
15	Northeast of Japan	52°N, 163°E	

Modeling was conducted for one 24-hour (hr) period in each of the four seasons in each model area. To predict acoustic exposure, the LFA sonar ship was simulated traveling in a triangular pattern at a speed of 4 kt (7.4 kph), with the time on each bearing (each “leg” of the triangle) being eight hours (480 minutes). The duration of LFA sonar transmissions was modeled as 24-hr, with a signal duration of 60 seconds and a duty cycle of 10 percent (i.e., the source transmitted for 60 seconds every 10 minutes for the 24-hr period, which equates to a total of 2.4 transmission hours). The acoustic field around the LFA sonar source was predicted with the Navy standard parabolic equation propagation model using the defined LFA sonar operating parameters. Each marine mammal species potentially occurring in a model area in each season was simulated by creating animats (model simulated animals) programmed with behavioral values describing their dive and movement patterns, including dive depth, dive duration, surfacing time, swimming speed, and direction change.

The AIM integrated the acoustic field created from the underwater transmissions of LFA sonar with the three-dimensional (3D) movement of marine mammals to estimate their potential sonar exposure at each 30-second timestep within the 24-hr modeling period. Thus, the output of AIM is the time history of exposure for each animat.

Since AIM records the exposure history for each individual animat, the potential impact is determined on an individual animal basis. The sound energy received by each individual animat over the 24-hr modeled period was calculated as SEL and the potential for that animal to experience a permanent threshold shift (PTS) in hearing and then a temporary threshold shift(TTS) in hearing was considered using NMFS (2018a) *[Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (Version 2.0)* (NOAA Technical Memorandum NMFS-OPR-59)] acoustic guidance thresholds. If an animal was not predicted to experience PTS or TTS, then the sound energy received over the 24-hr modeled period was calculated as a single ping equivalent (SPE) and used as input to the LFA risk continuum function to assess the potential risk of a behavioral reaction. A step-wise process was

undertaken to ensure that each individual is considered for only one potential impact (i.e., there is no double counting). The potential for PTS is considered first, as it represents the highest threshold. If an individual does not exceed the PTS threshold, then the potential for TTS is considered. If an animal does not exceed the TTS threshold, then the potential for a behavioral response is considered. Thus, individuals are only considered for one acoustic impact during a 24-hr exposure scenario.

To estimate the potential impacts for each marine mammal stock on an annual basis, several calculation steps were required. The first step was to calculate the potential impact for one LFA sonar transmission hour. The 24-hr modeling results for each season are for 2.4 transmission hours (i.e., the SURTASS LFA sonar was simulated to transmit at a 10 percent duty cycle, so 24 hours of LFA sonar use equate to 2.4 sonar transmission hours). Therefore, the impact estimates from 24 hours of LFA sonar use (2.4 transmission hours) were divided by 2.4 to transform the results into potential impacts on a per transmission hour basis. Because the use of SURTASS LFA sonar is not driven by any seasonal factors, and SURTASS LFA sonar training and testing activities are likely to occur with equal frequency in any of the four seasons, the per transmission hour impact estimates for each season were then averaged to provide a single annual per transmission hour impact estimate. At this point, the average impact of an hour of SURTASS LFA sonar transmissions during any time of the year has been calculated for every ESA-listed species (including Distinct Population Segments (DPSs)).

The second step for calculating the potential impacts from all SURTASS LFA sonar training and testing transmissions within a year is to determine the number of LFA sonar transmission hours that might occur in each model area, for each activity. To develop the total annual LFA sonar transmission hours, the Navy determined the training and testing activities that occur each year, the number of transmission hours conducted during each activity, and the model areas in which each activity is expected to occur (See Table 2), as not all proposed activities would occur in each of the modeled areas. To calculate the potential impact in each model area for each activity, the number of annual LFA sonar transmission hours for each activity was evenly distributed across the model areas in which that activity might occur. The hours were evenly distributed across model areas because there is an equal chance of activities happening in each model area identified for an activity; the Navy is not aware of any planning factors that would influence the distribution of activity hours among model areas. For example, the execution of vessel and equipment maintenance is estimated to require 64 total transmission hours, which are planned to occur only in either Model Area #2 or Model Area #3. Therefore, the 64 transmission hours were equally distributed to Model Areas #2 and #3, or 32 hours in each model area, for vessel and equipment maintenance activities.

Table 2. Activities and Maximum Transmission Hours Per Year Expected in each of the 15 Representative Model Areas.

Model Area Number/Name	***Activity (Transmission Hours Per Year)***					
	Contractor Crew Training (80)	***MILCREW Training (96)***	***Naval Exercises (96)***	***Maintenance (64)***	***Acoustic Research Testing (160)***	***Years 5+: New LFA Sonar System Testing (96)***
1 /East of Japan		X			X	X
2 /North Philippine Sea	X	X	X	X	X	X
3 /West Philippine Sea	X	X	X	X	X	X
4 /Guam		X	X		X	X
5 /Sea of Japan		X			X	X
6 /East China Sea		X			X	X
7 /South China Sea		X	X		X	X
8 /Offshore Japan (25 to		X			X	X
9 /Offshore Japan (10 to 25N)		X			X	X
10 /Hawaii-North		X	X		X	X
11 /Hawaii-South		X	X		X	X
12 /Offshore Sri Lanka		X			X	X
13 /Andaman Sea		X			X	X
14 /Northwest Australia		X			X	X
15 /Northwest Japan		X			X	X

The third step was to determine the number of model areas in which each ESA-listed species or DPS of marine mammals may occur for each activity. The fourth step was to select the maximum per hour effect for each species or DPS that may occur in the model areas for that activity. For instance, for maintenance activities (i.e., vessel and equipment maintenance) that

occur in model areas #2 and #3, if a species or DPS occurs in both model areas, whichever per hour effect estimate for that species or DPS was higher between the two modeling areas was selected for all subsequent calculations for estimating the effects from maintenance activities.

The final step was to multiply the results of steps two, three, and four to calculate the potential annual effects per activity, which are then summed across the stocks for a total potential effect for all activities. The maximum estimate of the per hour effect (result of step three) was multiplied by the planned transmission hours for each activity per model area (result of step two) and by the number of model areas in which the stock might occur for that activity (result of step four). The result is the maximum potential effect per stock for each activity, allowing flexibility for the activity to occur in any season and any of the planned model areas for that activity. These maximum effects per activity are summed across the marine mammal stocks/DPSs[1] for Years one to four (See Table 8) and Years five and beyond (See Table 9). For an in-depth example of how the U.S. Navy conducted this step by step quantitative modeling process, please see Chapter 4 of the Navy's Supplemental Environmental Impact Statement for SURTASS LFA Sonar (Navy 2018b).

2.1.1.1 Criteria for Assessing Effects to Marine Mammals from SURTASS LFA Sonar

Criteria for Auditory Effects (PTS and TTS)

In 2018, NMFS issued guidance on assessing the auditory effects of anthropogenic sound on marine mammals (NMFS 2018a). Specifically, NMFS' acoustic guidance identifies the received levels, or acoustic threshold levels, above which individual marine mammals are predicted to experience changes in their hearing sensitivity (PTS or TTS). These thresholds were implemented in the quantitative analysis of effects of SURTASS LFA sonar on marine mammals described in the section above. Further detail on the guidance is available in NOAA Technical Memorandum NMFS-OPR-59 (NMFS 2018a).

Recognizing that marine mammal species do not have equal hearing capabilities, the guidance defined five functional hearing groups of marine mammals:

- Low-frequency Cetaceans – this group consists of the mysticetes with a collective generalized hearing range of 7 Hz to 35 kHz.
- Mid-frequency Cetaceans – includes most of the dolphins, all toothed whales except for *Kogia* spp., and all the beaked and bottlenose whales with a generalized hearing range of approximately 150 Hz to 160 kHz.

[1] DPS is a discrete population or group of populations of the same species that is significant to the entire species. Populations are identified in this opinion as stocks under the MMPA and as DPSs under the ESA. The stocks and DPSs listed in this opinion denote the same populations. For example, the Western North Pacific humpback whale stock and DPS refer to the same population of humpback whales in this opinion.

- High-frequency Cetaceans – incorporates all the true porpoises, the river dolphins, plus *Kogia* spp., *Cephalorhynchus* spp. (genus in the dolphin family Delphinidae), and two species of *Lagenorhynchus* (Peale's and hourglass dolphins) with a generalized hearing range estimated from 275 Hz to 160 kHz.
- Phocids Underwater – consists of true seals with a generalized underwater hearing range from 50 Hz to 86 kHz.
- Otariids Underwater – includes sea lions and fur seals with a generalized underwater hearing range from 60 Hz to 39 kHz.

Within their generalized hearing ranges, the ability to hear sounds varies with frequency, as demonstrated by examining audiograms of hearing sensitivity (NMFS 2018a). To reflect higher noise sensitivities at particular frequencies, auditory weighting functions were developed for each functional hearing group that reflected the best available data on hearing ability (composite audiograms), susceptibility to noise-induced hearing loss, impacts of noise on hearing, and data on equal latency. These weighting functions are applied to individual sound received levels to reflect the hearing ability of each species to process received acoustic energy.

SURTASS LFA sonar is a non-impulsive source in that its signals do not have the high peak pressure with rapid rise time and decay that impulsive sounds do; instead, the pressure of the LFA sonar transmission is consistent throughout the signal. The acoustic threshold levels for non-impulsive sounds are defined as the cumulative sound exposure level (cSEL) over a 24-hour period with the appropriate frequency weighting for each functional hearing group, which is reflected in the subscript of each threshold (e.g., the low frequency cetacean threshold is identified as $L_{E,LF,24h}$, where $L_{E, LF, 24h}$ = low frequency sound exposure level(SEL) accumulated over 24 hours). The cumulative SEL metric takes into account both received level and duration of exposure over the duration of the activity within a 24-hour period. The TTS threshold is defined as 20 dB less than the PTS threshold. A summary of the cumulative sound exposure acoustic thresholds for PTS and TTS used in this analysis are provided in Table 3.

Table 3. Acoustic threshold levels for marine mammals exposed to non-impulsive sounds (NMFS 2018a)

Hearing Group	Permanent Threshold Shift Onset	Temporary Threshold Shift Onset
Low-frequency Cetaceans (LE,LF,24 hour)	199 dB SEL	179 dB SEL
Mid-frequency Cetaceans (LE,MF,24 Hour)	198 dB SEL	178 dB SEL
High-frequency Cetaceans (LE,HF,24 Hour)	173 dB SEL	153 dB SEL
Phocid Pinnipeds Underwater (LE,PW,24 Hour)	201 dB SEL	181 dB SEL

Otariid Pinnipeds Underwater (LE,OW,24 Hour)	219 dB SEL	199 dB SEL

LE, X, 24 Hour=Frequency SEL Accumulated over 24 Hour
LF=Low-Frequency
MF=Mid-Frequency
HF=High-Frequency
PW=Phocids Underwater
OW=Otariids Underwater

Assessing the Potential for Behavioral Response

The Low Frequency Sound Scientific Research Program (LFS SRP) in 1997 through 1998 provided results on the responses of baleen whales when exposed to SURTASS LFA sonar signals and the way those responses scaled relative to received level and context. The LFS SRP experiments continue to represent the most relevant predictions of the potential for behavioral changes from exposure to LFA sonar. The results of the LFS SRP confirmed that some portion of the total number of whales exposed to LFA sonar responded behaviorally by changing their vocal activity, moving away from the source vessel, or both; but the responses were short-lived and animals returned to their normal activities within tens of minutes after initial exposure (Clark and Fristrup 2001a). Perhaps the most important result came from the LFS SRP Phase II study, where the LFA sonar stimulus was presented to migrating gray whales. When the source was in the migratory path, the whales diverted around the source at received levels of 170 to 178 dB re: 1 μPa root mean square (rms). However, when the source was moved offshore to the edge of the migratory corridor, with an increased source level (SL) to maintain the same received levels at the whales, the migrating gray whales exhibited no response to the LFA stimulus (Clark 1999). The context of an exposure scenario is clearly important for determining the probability, magnitude, and duration of a behavioral response (Ellison et al. 2012a).

The results of the LFS SRP were used to derive the LFA risk continuum function, from which the potential for biologically significant behavioral response is calculated as described in the impact analysis section below. This function has been described in detail in previous Navy documentation for SURTASS LFA sonar (Navy 2001a; Navy 2001b; Navy 2007; Navy 2012; Navy 2017b), which as previously noted are incorporated by reference. The risk continuum is based on the premise that a smooth, continuous function that maps received level to risk is most appropriate for defining the potential or risk for a biologically significant behavioral response (Figure 1). A summary of the risk continuum function follows; additional details are available in the 2012 or 2017 SURTASS LFA sonar environmental impact statements(Navy 2012; Navy 2017b).

The parameters of the risk continuum function are based on the LFS SRP results. These experiments, which exposed baleen whales to received levels ranging from 120 to about 155 dB re: 1 μPa (rms), detected only minor, short-term behavioral responses. Short-term behavioral responses do not necessarily constitute significant changes in biologically important behaviors.

The fact that none of the LFS SRP observations revealed a significant change in a biologically important behavior helped determine an upper bound for risk. However, the LFS SRP results cannot be used to prove that there is zero risk at these levels. Accordingly, the risk continuum assumes that risk is small, but not zero, at the received levels achieved during the LFS SRP. The basement value below which risk is negligible is 120 dB single ping equivalent (SPE). Fifty percent risk of a behavioral response is defined at 165 dB SPE. The steepness of the curve, termed the risk-transition-sharpness-parameter, is defined as 10 for LFA sonar.

The risk continuum modeled a smooth increase in risk that culminates in a 95 percent level of risk of significant change in a biologically important behavior at 180 dB SPE. In this region, the risk continuum is unsupported by observations. Since the risk continuum function was derived from the behavioral response data of baleen whales collected with an actual SURTASS LFA sonar source, these data are realistic contextually and remain the best available for the response of low frequency-sensitive marine mammals to the SURTASS LFA sonar source.

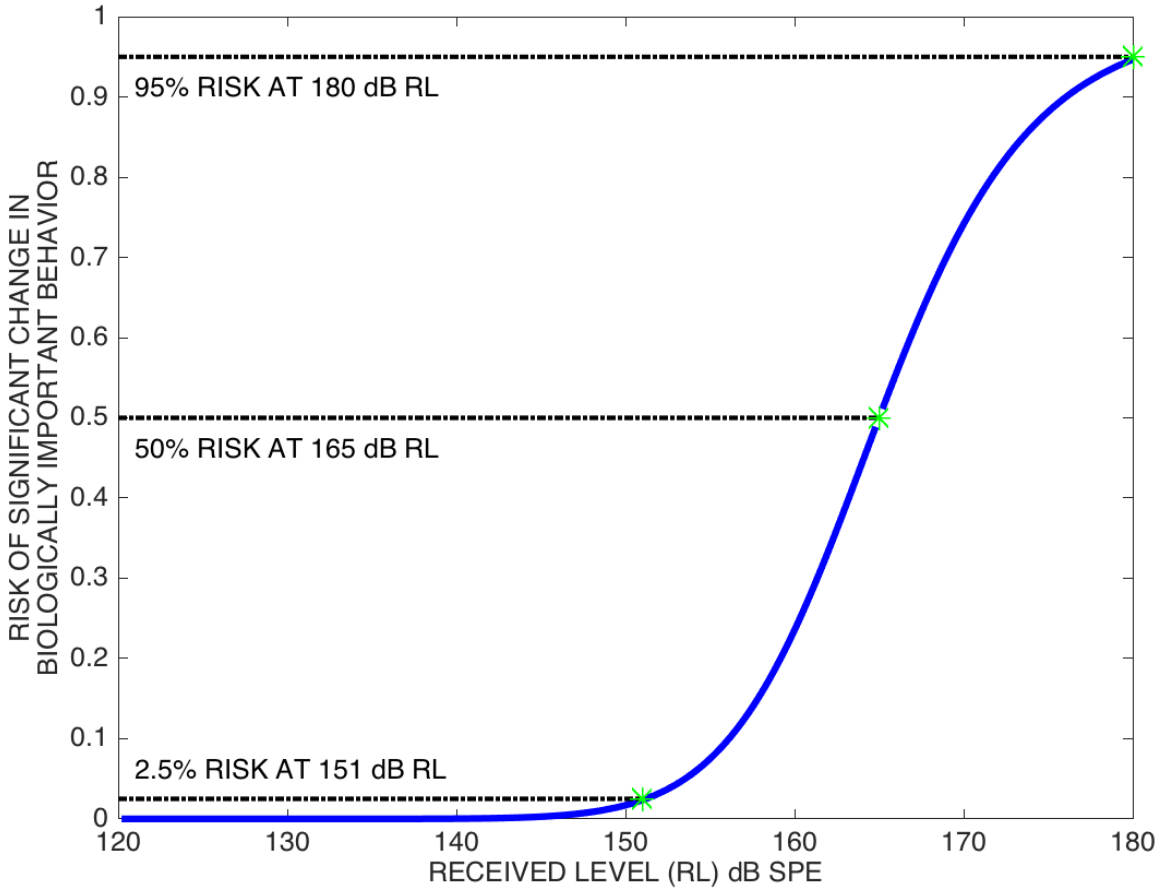

Figure 1. Risk continuum function for Surveillance Towed Array Sensor System (SURTASS) Low Frequency Active (LFA) sonar that related the risk of significant

change in biologically important behavior to received levels in decibels, single ping equivalent (SPE).

The Navy uses the risk continuum function for SURTASS LFA sonar to quantify the number of behavioral responses that could qualify as Level B (behavioral) harassment under the MMPA. This includes a wide range of behavioral reactions such as avoidance of the sound source, temporary changes in vocalizations or dive patterns, temporary avoidance of an area, or temporary disruption of feeding, migrating, or reproductive behaviors. The estimates calculated using the risk continuum function do not differentiate between the different types of potential reactions nor the significance of those potential reactions. These estimates also do not provide information regarding the potential fitness or other biological consequences of the reactions on the affected individuals. Therefore, our effects analysis considers the available scientific evidence to determine the likely nature of the Navy's modeled behavioral responses and potential fitness consequences for affected individuals.

2.1.1.2 *Occurrence and Population Estimates of Marine Mammals in the Action Area for SURTASS LFA Sonar*

Marine mammals are not homogeneously distributed throughout the action area for SURTASS LFA sonar. To effectively evaluate impacts to marine mammals potentially associated with SURTASS LFA sonar activities, information is not only needed about which marine mammals occur in all regions of the vast action area for SURTASS LFA sonar in the western and central North Pacific and eastern Indian oceans but also about when and how many are found in the action area. As a result, the Navy used a temporal and spatial framework to partition the action area and effective period into manageable components.

Since the behavioral ecology of most marine mammal species is mediated by seasonally driven changes in light, temperature, and associated prey availability, standard seasons were used as the temporal framework. The Navy used four seasons defined according to the following monthly:

- Winter: December, January, and February
- Spring: March, April, and May
- Summer: June, July, and August
- Fall: September, October, and November.

This seasonality is based on the Northern Hemisphere. For the part of the action area for SURTASS LFA sonar that lies in the Southern Hemisphere, austral seasons pertain, which are the reverse of this standard timeframe. Austral winter occurs from June through August while austral summer lasts from December through February.

Deriving a spatial framework for the effects analysis required consideration of the geographic usage constraints (i.e., coastal standoff range) of SURTASS LFA sonar, the Navy's national security purpose for conducting SURTASS LFA sonar testing and training activities, and appropriate acoustic and environmental conditions. The Navy devised a spatial framework of 15

representative areas to model SURTASS LFA sonar activities in the central and western North Pacific and eastern Indian oceans that represent the acoustic regimes and marine mammal species potentially encountered during covered LFA sonar activities (Table 1).

With this spatial and temporal framework in place, deriving the associated marine mammal species and associated population numbers for each model area in each season was required. Marine mammal stocks and DPSs, as appropriate, were defined for each marine mammal species in each of the modeling areas. The potentially occurring marine mammal species, stocks, and DPSs for each modeling area were verified with distributional information and data from published scientific literature; government reports, including NMFS's stock assessment reports (SARs) for U.S. waters; and information from international organizations such as the IUCN and IWC.

For most cetacean species, abundances and densities were estimated using line-transect surveys or mark-recapture studies (See Table 4), which usually provide a single abundance or density estimate for each species observed across broad geographic areas, such as waters within the United States Economic Exclusion Zone (U.S. EEZ) off Hawaii. Though the single abundance or density provides a good average estimate of the total number of individuals in a specified area, it does not provide information on the species distribution or concentrations outside that limited area nor does it provide abundance or density estimates for other seasons that were not surveyed.

The process for developing abundance and density estimates for every species/stock in the 15 potential model areas in all seasons was a multi-step procedure. In modeling areas where no abundance estimates were available for a stock, a surrogate abundance was required. A surrogate abundance estimate derived for a similar oceanographic area for the same species or a conspecific was used. For example, population-level data for the majority of marine mammal stocks in the Indian Ocean is scarce. As a result, the Navy used surrogate data for the same species in a marine area with similar oceanographic and ecological characteristics. Abundance estimates were derived using the best available information and data (Table 4), including the most up-to-date NMFS SARs for U.S. Pacific waters (Carretta et al. 2019; Muto et al. 2019).

When deriving density estimates for the 15 model areas, direct estimates from line-transect (sighting) surveys that occurred in or near the representative model areas were utilized first (Barlow 2006). However, density estimates were not always available for each species/stock in all model areas. In areas where survey data are limited or non-existent, known or inferred habitat associations were used to predict densities. When density estimates derived from line-transect or other surveys were not available in a model area, then density estimates from a region with similar oceanographic/environmental characteristics were extrapolated to that model area and species/stock. For example, the eastern tropical Pacific has been extensively surveyed for marine mammals, with those survey data providing a comprehensive understanding of marine mammals in tropical and warm-temperate oceanic waters (Wade and Gerrodette 1993; Ferguson and Barlow 2001b). Data from such well-studied areas are the foundation for population estimates of

data-poor species of the western North Pacific and Indian Oceans, where stock and population-level data are scarce. Further, density estimates are sometimes pooled for species of the same genus if sufficient data are not available to compute a density for individual species. This is often the case for pilot whales, beaked whales, and pygmy and dwarf sperm whales (*Kogia* spp.). Density estimates are often available for these species-groups rather than the individual species in some model areas. Last, density estimates are usually not available for very rare marine mammal species or for those that have been newly defined (e.g., the Deraniyagala's beaked whale). For such species, the lowest density estimate of 0.00001 animals per square kilometer (animals/km^2) was used to reflect the very low potential of occurrence in a specific SURTASS LFA sonar model area for data sparse species, such as the North Pacific right whale.

Density estimates for the potentially occurring marine mammal stocks in the modeled areas located in the Indian Ocean were derived from one source (Table 4), the Navy's Marine Species Density Database (NMSDD) (Navy 2018c). The NMSDD provides a systematic method for selecting the most appropriate density value for each species' stock in a given area and season. The NMSDD integrates direct survey sighting data with distance sampling theory to convolve designed-based density estimates, stratified-designed based density estimates, estimates from density spatial models, and habitat-suitability index models to result in spatially and seasonally explicit densities for most marine mammal species. Currently, the NMSDD is not publically available since proprietary geospatial modeling data are included in the database, for which the Navy has established proprietary data sharing agreements. However, products of the Navy's database have been made available to the public, such as the *U.S. Navy Marine Species Density Database Phase III for the Hawaii-Southern California Training and Testing Study Area, NAVFAC Pacific Technical Report* (Navy 2017d). This report has been used to support Navy environmental compliance documentation for Pacific testing and training areas. The citations for the sighting surveys or other data upon which the densities were derived in the NMSDD have been cited and incorporated herein when appropriate. Densities derived from the NMSDD for the potentially occurring marine mammal stocks were averaged over each modeled area during each season.

Predictions of potential environmental impacts are largely influenced by the accuracy with which the marine mammal abundances and densities are estimated for the selected geographic area and season, which is indicated with measures of uncertainty associated with the population estimates**.** Uncertainty in abundance and density estimates is typically expressed by the coefficient of variation (CV), which is calculated using standard statistical methods and describes the uncertainty as a percentage of the population mean. A CV can range upward from zero, indicating no uncertainty, to higher values approaching one that connotes a higher level of uncertainty about the population estimate. For example, a CV of 0.85 (or 85 percent) would indicate high uncertainty in a given population estimate. When the CV exceeds 1.0, the estimate is very uncertain. Another method for characterizing uncertainty is a confidence interval (CI). This expression typically relates to the 95 percent probability that the "true" population value

falls within the given CI range of values. Therefore, a CI with a wider range of values (e.g., 150 to 550) indicates that there is greater uncertainty about the true value than a CI with a smaller range of values (e.g., 300 to 400).

When sufficient information about seasonal movements was available for marine mammal stocks in model areas or ocean regions, that seasonality is reflected in the density estimates. Density estimates were truncated to no more than five decimal places (See Table 4 below). The references used for these density estimates are presented in Appendix A (See Section 16).

Table 4. Marine Mammal Species, Stocks, Distinct Population Segments (DPSs), Abundances, and Density Estimates by Season as well as the Associated References for the 15 Proposed SURTASS LFA Modeling Areas in the Central and Western North Pacific Ocean and Eastern Indian Ocean[2]

Marine Mammal Species	*Stock Name*[3]	*Abundance*	*Abundance References*	*Density (animals per km²)*[4]				*Density Reference(s)*
				Winter	*Spring*	*Summer*	*Fall*	
Model Area #1: East of Japan								
Blue whale	WNP	9,250	1	0.00001	0.00001		0.00001	1, 2, 3, 4
Fin whale	WNP	9,250	1, 7			0.0002	0.0002	1
Humpback whale	WNP stock and DPS[5]	1,328	8			0.00036	0.00036	4, 38
North Pacific right whale	WNP	922	9	0.00001	0.00001			
Sei whale	NP	7,000	1, 10	0.00029	0.00029	0.00029	0.00029	11
Sperm whale	NP	102,112	12	0.00123	0.00123	0.00123	0.00123	11
Model Area #2: North Philippine Sea								
Blue whale	WNP	9,250	1	0.00001	0.00001		0.00001	1, 2, 3, 4
Fin whale	WNP	9,250	1, 7	0.0002	0.0002			1
Humpback whale	WNP stock and DPS	1,328	8	0.00089	0.00089		0.00089	4, 14
North Pacific right whale	WNP	922	9	0.00001	0.00001			
Sperm whale	NP	102,112	12	0.00123	0.00123	0.00123	0.00123	11
Model Area #3: West Philippine Sea								
Blue whale	WNP	9,250	1	0.00001	0.00001		0.00001	1, 2, 3, 4
Fin whale	WNP	9,250	1, 7	0.0002	0.0002			1

2 References listed in Appendix A (See Section 16)

3 NP=North Pacific; WNP=Western North Pacific; CNP=Central North Pacific; WP=Western Pacific; ECS=East China Sea; IND=Indian; NIND=Northern Indian; SIND=Southern Indian

4 No density in a season means that the marine mammal is not expected to occur in that model area during that season.

5 DPS=distinct population segment, which is a discrete population or group of populations of the same species that is significant to the entire species. Populations are identified as stocks under the MMPA and as DPSs under the ESA. Thus, the humpback whale and other species are listed by stock and DPS (DPS/stock) where relevant. The stocks and DPSs listed in this table are equivalent.

Marine Mammal Species	*Stock Name*[3]	*Abundance*	*Abundance References*	*Density (animals per km²)*[4]				*Density Reference(s)*
				Winter	*Spring*	*Summer*	*Fall*	
Humpback whale	WNP stock and DPS	1,328	8	0.00089	0.00089		0.00089	4, 14
Sperm whale	NP	102,112	12	0.00123	0.00123	0.00123	0.00123	11
Model Area #4: Offshore Guam								
Blue whale	WNP	9,250	1	0.00005	0.00006		0.00005	22
Fin whale	WNP	9,250	1, 7	0.00006	0.00006		0.00006	22
Humpback whale	WNP stock and DPS	1,328	8	0.00089	0.00089		0.00089	4, 14
Sei whale	NP	7,000	10	0.00029	0.00029		0.00029	11
Sperm whale	NP	102,112	12	0.00123	0.00123	0.00123	0.00123	13
Model Area #5: Sea of Japan								
Fin whale	WNP	9,250	1, 7	0.0009	0.0009		0.0009	2, 3
North Pacific right whale	WNP	922	9	0.00001	0.00001			
Western North Pacific gray whale	WNP stock/ Western DPS	290	5	0.00001	0.00001	0.00001	0.00001	
Sperm whale	NP	102,112	12	0.00123	0.00123	0.00123	0.00123	11
Spotted seal	Southern stock and DPS	6,284	16, 40, 41, 42	0.00001	0.00001	0.00001	0.00001	
Model Area #6: East China Sea								
Fin whale	ECS	500	1, 7, 19	0.0002	0.0002	0.0002	0.0002	1
North Pacific right whale	WNP	922	9	0.00001	0.00001			
Western North Pacific gray whale	WNP stock/ Western DPS	290	5	0.00001	0.00001		0.00001	
Sperm whale	NP	102,112	12, 13	0.00123	0.00123	0.00123	0.00123	11
Spotted seal	Southern stock and DPS	1,500	16,41	0.00001	0.00001	0.00001	0.00001	
Model Area #7: South China Sea								
Fin whale	WNP	9,250	1, 7	0.0002	0.0002		0.0002	1
Humpback whale	WNP stock and DPS	1,328	8	0.00036	0.00036		0.00036	4, 38
North Pacific right whale	WNP	922	9	0.00001	0.00001			

Marine Mammal Species	Stock Name[3]	Abundance	Abundance References	Density (animals per km^2)[4]				Density Reference(s)
				Winter	Spring	Summer	Fall	
Western North Pacific gray whale	WNP stock/ Western DPS	290	5	0.00001	0.00001		0.00001	
Sperm whale	NP	102,112	12	0.0012	0.0012	0.0012	0.0012	11
Model Area #8: Offshore Japan/Pacific (25º to 40ºN)								
Blue whale	WNP	9,250	1	0.00001	0.00001		0.00001	1, 2, 3, 4
Fin whale	WNP	9,250	1, 7			0.0001	0.0001	1
Humpback whale	WNP stock and DPS	1,328	8			0.00036	0.00036	4, 38
Sei whale	NP	7,000	10		0.00029	0.00029	0.00029	11
Sperm whale	NP	102,112	12, 13	0.0022	0.0022	0.0022	0.0022	20
Hawaiian monk seal	Hawaii	1,427	21	0.00001	0.00001	0.00001	0.00001	
Model Area #9: Offshore Japan/Pacific (10° to 25°N)								
Blue whale	WNP	9,250	1, 5, 6	0.00001	0.00001		0.00001	1, 2, 3, 4
Fin whale	WNP	9,250	1	0.00001	0.00001			
Humpback whale	WNP stock and DPS	1,328	8	0.00036	0.00036		0.00036	4, 38
Sei whale	NP	7,000	10	0.0029			0.0029	11
Sperm whale	NP	102,112	12	0.00222	0.00222	0.00222	0.00222	20
Model Area #10: Hawaii North								
Blue whale	CNP	133	22	0.00005	0.00005		0.00005	22
Fin whale	Hawaii	154	22	0.00006	0.00006		0.00006	22
Sei whale	Hawaii	391	22	0.00016	0.00016		0.00016	22
False killer whale	Main Hawaiian Islands Insular stock and DPS	167	5, 24	0.0008	0.0008	0.0008	0.0008	25
Sperm whale	Hawaii	4,559	22	0.00158	0.00158	0.00158	0.00158	27
Hawaiian monk seal	Hawaii	1,427	21	0.00004	0.00004	0.00004	0.00004	21, 28
Model Area #11: Hawaii South								
Blue whale	CNP	133	22	0.00005	0.00005		0.00005	22
Fin whale	Hawaii	154	22, 23	0.00006	0.00006		0.00006	22
Sei whale	Hawaii	391	22	0.00016	0.00016		0.00016	22

Marine Mammal Species	Stock Name[3]	Abundance	Abundance References	Density (animals per km^2)[4]				Density Reference(s)
				Winter	Spring	Summer	Fall	
False killer whale	Main Hawaiian Islands Insular stock and DPS	167	5, 24	0.0008	0.0008	0.0008	0.0008	25
Sperm whale	Hawaii	4,559	22	0.00131	0.00131	0.00131	0.00131	27
Hawaiian	Hawaii	1,427	21	0.00004	0.00004	0.00004	0.00004	21, 28
Model Area #12: Offshore Sri Lanka								
Blue whale	NIND	3,691	29	0.00004	0.00004	0.00004	0.00004	28
Fin whale	IND	1,846	29	0.00001	0.00001	0.00001	0.00001	28
Sei whale	NIND	9,176	29, 30	0.00141	0.00045	0.00045	0.00095	28
Sperm whale	NIND	24,446	29, 30	0.00129	0.00118	0.00126	0.00121	28
Model Area #13: Andaman Sea								
Blue whale	NIND	3,691	29	0.00003	0.00003	0.00003	0.00003	28
Fin whale	IND	1,846	29	0.00001	0.00001		0.00001	28
Sperm whale	NIND	24,446	30	0.00109	0.00099	0.00107	0.00105	28
Model Area #14: Northwest of Australia[6]								
Blue whale	SIND	1,657	31, 32		0.00003	0.00003	0.00003	28
Fin whale	SIND	38,185	33, 34	0.00001	0.00099	0.00128	0.00121	28
Sei whale	SIND	13,854	35	0.00001	0.00001	0.00001	0.00001	
Sperm whale	SIND	24,446	30	0.00096	0.00087	0.00097	0.00092	28
Model Area #15: Northeast of Japan								
Blue whale	WNP	9,250	1	0.00001	0.00001		0.00001	1, 2, 3, 4
Fin whale	WNP	9,250	1		0.0002	0.0002	0.0002	1
Humpback whale	WNP stock and DPS	1,328	8		0.000498	0.000498	0.000498	28
North Pacific right whale	WNP	922	9			0.00001	0.00001	
Sei whale	NP	7,000	10		0.00029	0.00029		11
Western North Pacific gray whale	WNP stock/ Western DPS	290	5			0.00001	0.00001	
Sperm whale	NP	102,112	12	0.0017	0.0022	0.0022	0.0022	20

6 Seasons are presented following Northern Hemisphere monthly breakdowns for consistency. That is, winter for this model area would actually be austral summer in the Southern Hemisphere where this model area is located.

Marine Mammal Species	*Stock Name*[3]	*Abundance*	*Abundance References*	*Density (animals per km²)*[4]				*Density Reference(s)*
				Winter	*Spring*	*Summer*	*Fall*	
Western Steller sea lion	Western/ Asian stocks/Western DPS	77,767	23, 37	0.00001	0.00001	0.00001	0.00001	

2.1.2 Approach to Assessing Effects to Sea Turtles

The Navy did not use AIM to assess the exposure and response of sea turtles to SURTASS LFA sonar because such an analysis would require adequate information on the distribution and density of sea turtles species in the open ocean and this information is not currently available. The best available population estimates (abundances) for all sea turtle species are typically underestimates as they nearly always are nesting counts of females when they come ashore to nest and lay their eggs. Some nearshore foraging hotspots have been identified for loggerhead turtles (Seminoff et al. 2014). Additionally, nearshore breeding aggregations have been identified for some species (i.e., olive ridley). However, the density of turtles observed in these locations is very different from what would be expected in the open ocean environments where SURTASS LFA sonar will operate. Nearly all species of sea turtles occur in low numbers over most of their ranges, resulting in widely dispersed and variable distributions in the open ocean. Coupled with low numbers dispersed over enormous geographic areas is the additional complexity of some sea turtle's life stages, such as the leatherback and olive ridley turtles, which spend their entire lives dispersed widely in pelagic waters, while the early life stages of other sea turtle species spend only the "lost years" drifting around the central ocean gyres. For these reasons, NMFS and the Navy were unable to provide sea turtle density estimates to use in the exposure analyses and we are unable to estimate the number of sea turtle exposed to, and potentially affected by, the operation of SURTASS LFA sonar, which is used to estimate take.

However, we can use available information on the effectiveness of the mitigation proposed during operation of SURTASS LFA sonar to minimize adverse effects to sea turtles, sea turtle densities in the open ocean environment, how sea turtles use underwater sound, and how sea turtles respond to sound exposures to assess the likely effects of the operation of SURTASS LFA sonar on ESA-listed sea turtles. This analysis is presented in Section 8.3 and 8.5 of this opinion.

3 DESCRIPTION OF THE PROPOSED ACTION

"Action" means all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by federal agencies.

This consultation considered three interdependent actions proposed by the U.S. Navy and NMFS' Permits and Conservation Division: (1) the U.S. Navy's proposed action to employ SURTASS LFA sonar during routine training and testing activities on Navy vessels in the western and central north Pacific and eastern Indian Oceans from August 2019 and continuing into the reasonably foreseeable future. This will include 496 total transmission hours of SURTASS LFA sonar for the first four years of activities and 592 transmission hours during the last three years to accommodate future testing of new ocean surveillance vessels and new or updated sonar system components. (2) NMFS' Permits and Conservation Division's promulgation of MMPA regulations, which are limited to periods of not more than seven consecutive years for military readiness activities. As described previously, this consultation will review seven years of SURTASS LFA sonar activity instead of five years due to recent provisions added to the NDAA, which amended MMPA regulations by increasing previous five-year MMPA rulemakings to seven years for military readiness activities. The MMPA regulations will govern the take of marine mammals and allow NMFS' Permits and Conservation Division to issue a LOA that would authorize the Navy to take marine mammals incidental to their SURTASS LFA sonar training and testing activities. (3) NMFS' Permits and Conservation Division's issuance of a LOA under the regulations that authorize the Navy to take marine mammals during its SURTASS LFA sonar training and testing activities in the western and central North Pacific and Indian Oceans. The approach of addressing interdependent actions is consistent with Congress' intent that we coordinate and integrate the decision-making process under the MMPA and ESA to the maximum extent practicable. Therefore, this consultation considers both the Navy's actions and NMFS' Permit and Conservation Divisions related actions.

Consistent with 50 CFR §402.14(i)(6), this consultation includes an analysis of a framework for the development of future actions (i.e., the proposed regulations governing the take of marine mammals) and where sufficient information is available, an analysis of the likely effects of these future actions on ESA-listed resources. Where sufficient information is available and take is reasonably certain to occur, this consultation includes an incidental take statement (ITS).

This consultation assumes that the Navy's SURTASS LFA sonar training and testing activities will be used in the model areas proposed for the period of August 13, 2019 and continuing into the reasonably foreseeable future, and at levels no higher than permitted by the MMPA regulation. In the event of projected changes to the activity or to mitigation and monitoring measures required by the seven-year LOA (excluding changes made pursuant to the adaptive management provision of 50 CFR § 218.239), the Navy must apply for and obtain a modification of the LOA as described in 50 CFR § 218.238.

Additionally, NMFS recognizes that while the Navy's SURTASS LFA sonar routine training and testing requirements may change over time and other factors, the general types of activities addressed by this consultation are expected to continue into the reasonably foreseeable future, along with the associated impacts. Therefore, as part of our effects analysis, we also assumed that the activities proposed for the period of August 13, 2019, to August 12, 2026, would continue into the reasonably foreseeable future at levels and locations similar to that described in this opinion, and we considered the direct and indirect effects of those assumed future activities, together with the effects of all interrelated and interdependent actions. This approach addresses the court decision in *Intertribal Sinkyone Wilderness Council v. National Marine Fisheries Service et al.*, No. 1:12-cv-00420-NJV (N.D. Ca. September 25, 2013), although we may consider a different approach in future actions.

Notwithstanding this analysis, however, NMFS would fully take into account all of the best available science and any change in the status of the species when and if the Navy applies for a new MMPA Incidental Take Authorization for SURTASS LFA sonar training and testing activities upon expiration of the seven-year regulations considered during this consultation. The Navy would also need to initiate a new ESA section 7 consultation at that time.

3.1 The Navy's Proposed Action

The Navy's primary mission is the maintenance, training, equipping, and operation of combat-ready naval forces capable of accomplishing America's strategic objectives, deterring maritime aggression, and maintaining freedom of navigation in ocean areas. The Secretary of the Navy is responsible for functions such as training, supplying, equipping, and maintaining naval forces that are ready to achieve national security objectives as directed by the National Command Authorities. Preparing and maintaining forces skilled in anti-submarine warfare (ASW) is a critical part of the Navy's mission. Due to the advancements and use of quieting technologies in diesel-electric and nuclear submarines, undersea submarine threats have become increasingly difficult to locate solely using passive acoustic technologies. At the same time, the distance at which submarine threats can be detected decreases due to these quieting technologies, and improvements in torpedo and missile design have extended the effective range of these weapons. The Navy developed SURTASS LFA sonar to meet the need for long-range submarine detection and continues to use the sonar system onboard Navy ocean surveillance ships for the same purpose. The Proposed Action furthers the Navy's execution of its congressionally mandated roles and responsibilities under 10 U.S.C. Section 5062.

The Navy proposes to continue utilizing SURTASS LFA sonar systems onboard United States Naval Ship (USNS) surveillance ships for training and testing conducted under the authority of the Secretary of the Navy in the western and central North Pacific and eastern Indian oceans. This does not include use of SURTASS LFA sonar in armed conflict, direct combat support operations, or use of SURTASS LFA sonar in support of military operations directed by the National Command Authorities.

The Navy currently has four surveillance ships that are equipped with SURTASS LFA sonar systems: USNS VICTORIOUS (Tactical-Auxiliary General Ocean Surveillance [T-AGOS] 19); USNS ABLE (T-AGOS 20); USNS EFFECTIVE (T-AGOS 21); and USNS IMPECCABLE (T-AGOS 23). The Navy may develop and field additional SURTASS LFA sonar equipped vessels, either to replace or complement the Navy's current SURTASS LFA sonar-capable fleet. The Navy proposes to use SURTASS LFA sonar systems onboard these vessels within the action area, which includes the western and central North Pacific and eastern Indian oceans. Although past SURTASS LFA sonar actions have been worldwide, the Navy has narrowed the geographic scope of the current proposed action to reflect only those areas of the world's oceans where the Navy anticipates conducting covered SURTASS LFA sonar activities in the foreseeable future. The narrowed scope would allow the Navy to more accurately assess and describe only those impacts associated with SURTASSS LFA sonar activities in areas where the Navy expects to conduct these activities.

The Navy proposes to implement procedural and geographic mitigation measures in association with the use of SURTASS LFA sonar. Specifically, the Navy would ensure that received levels of LFA sonar transmissions are below 180 dB re 1 µPa (rms) within 12 nautical miles (nmi) (22 km) of any emergent land and one km (0.5 nmi) seaward of the outer perimeter of any designated offshore biologically important areas (OBIAs) during their effective periods of important biological activity. Procedural mitigation measures include visual, passive acoustic, and active acoustic (high frequency marine mammal monitoring [HF/M3] sonar) monitoring to minimize effects to marine animals when SURTASS LFA sonar is transmitting by providing the means to detect marine mammals and sea turtles in the LFA mitigation/buffer zone for SURTASS LFA sonar, and then suspending or delaying LFA sonar transmissions if marine animals are detected. Additionally, the received levels of LFA sonar transmissions would not exceed 145 dB re 1 µPa (rms) within known recreational dive sites.

Currently under the NDE, the Navy is authorized to transmit a maximum of 255 hours of LFA sonar transmission hours per vessel per year or 1,020 total transmission hours per year for testing and training activities and routine military operations. The Navy proposes to transmit a maximum of 496 total hours of LFA sonar transmissions per year pooled across all SURTASS LFA sonar-equipped vessels in the first four years of the effective period of the proposed regulations, with increased sonar usage in years five through seven of a maximum of 592 total hours of LFA sonar transmissions, regardless of the number of vessels, for testing and training activities.

In years five through seven of the authorization, the Navy is planning to add new vessels to its ocean surveillance fleet. As new vessels are developed, the onboard LFA and HF/M3 sonar systems may also need to be updated, modified, or even re-designed. As the new vessels and sonar system components are developed and constructed, at-sea testing would eventually be necessary. The Navy anticipates that new vessels or new or updated sonar system components would be ready for at-sea testing beginning in the fifth year of the effective period covered by

this BE. Thus, the Navy's activity analysis included consideration of the sonar hours associated with future testing of new or updated LFA sonar system components and new ocean surveillance vessels. This consideration resulted in two scenarios of annual sonar transmit hours: Years 1 to 4 would entail 496 hours total per year across all SURTASS LFA sonar vessels, while year five and beyond would include an increase in LFA sonar transmit hours to 592 hours across all vessels to accommodate future testing of new ocean surveillance vessels and new or updated sonar system components.

The SURTASS LFA sonar transmission hours represent a distribution across six activities that include:

- Contractor crew proficiency training (80 hours per year)
- Military crew (MILCREW) proficiency training (96 hours per year)
- Participation in or support of Navy exercises (96 hours per year)
- Vessel and equipment maintenance (64 hours per year)
- Acoustic research testing (160 hours per year)
- New SURTASS LFA sonar system testing (96 hours per year; would occur in year 5 and beyond)

Each of these activities utilize the SURTASS LFA sonar system within the operating profile that follows. Thus, the number of hours estimated for each activity is intended for planning purposes.

3.2 Description of the Surveillance Towed Array Sensor System (SURTASS) Low Frequency Active (LFA) Sonar System

SURTASS LFA sonar is a long-range system operating in the low frequency (LF) band (below 1,000 Hertz [Hz]). This system is composed of both active and passive components. The active component is the LFA sonar source array and the passive component is the SURTASS receive array. Sonar is a term that is used to define any system that uses underwater sound, or acoustics, for observations and communications. Sonar systems are used for many purposes, ranging from commercial "fish finders" to military ASW systems used for detection and classification of submarines.

The SURTASS LFA sonar system uses two basic types of sonar:

- Passive sonar detects the sound created by an object (source) in water. This is a one-way transmission of sound waves through water from the source to the receiver and is the same as people hearing sounds that are created by a source and transmitted through the air to the ear. Very simply, passive sonar "listens" or receives sound signals without sending or transmitting any sound signals itself.
- Active sonar detects objects by creating a sound pulse or "ping" that travels through the water and reflects off a target, then returns as an echo that is detected by a receiver (such as SURTASS). Active sonar is a two-way transmission (source to reflector to receiver).

Some marine mammals use a type of active biosonar called echolocation to locate underwater objects such as prey or the seafloor for navigation.

The SURTASS LFA sonar system is installed on USNS IMPECCABLE (T-AGOS 23), but as future undersea warfare requirements transitioned to littoral[7] ocean regions, a compact version of the LFA sonar system deployable on SURTASS surveillance ships was needed. The Navy developed CLFA, which consists of smaller, lighter-weight source elements than the original SURTASS LFA sonar system that is compact enough to be installed on the VICTORIOUS class platforms (i.e., T-AGOS 19, 20, and 21). CLFA sonar improvements include:

- Operational frequency, within the 100 to 500 Hz range, matched to shallow-water environments with little loss of detection performance in deep-water environments.
- Improved reliability and ease of deployment.
- Lighter-weight design (44 percent lighter than the original LFA sonar system).

The operational characteristics of the CLFA sonar system are comparable to the full-sized LFA sonar system. As such, the potential effects associated with CLFA sonar are expected to be similar to, and not greater than, the effects associated with the LFA sonar system. For this reason, as previously noted, the term LFA sonar refers inclusively of both the LFA and/or the CLFA sonar systems, unless otherwise specified.

3.2.1 Passive Sonar System Components

SURTASS is the passive, or listening, component of the system that detects returning echoes from submerged objects, such as threat submarines, though the use of hydrophones. Hydrophones transform mechanical energy (received acoustic sound waves) to an electrical signal that can be analyzed by the processing system of the sonar. SURTASS consists of a twin-line (TL-29A) horizontal line array (HLA), which is a “Y” shaped array with two apertures that is approximately 1,000 feet (ft) (305 meters(m)) long and has an operational depth of 152.4 to 457.2 m (500 to 1,500 ft). The TL-29A can be towed in shallow, littoral environments; provides significant directional noise rejection; and resolves bearing ambiguities without having to change the vessel’s course.

To tow the HLA, a Navy ocean surveillance vessel typically maintains a speed of at least 3 knots (kt) (5.6 kph). The return (received) signals, which are usually below background or ambient noise level, are processed, and evaluated to identify and classify potential underwater threats.

[7] The Navy defines “littoral” as the region that horizontally encompasses the land/water interface from 50 statute miles (80 km) ashore to 200 nmi (370 km) at sea; this region extends vertically from the seafloor or land to the top of the atmosphere (Naval Oceanographic Office, 1999). The common definition of littoral refers to shore or a shore or coastal region, while the marine science definition refers to the shallow-water zone between low- and high-tide. The Navy’s meaning differs because it is based on a tactical perspective, not a geographical or environmental, that relates to overall coastal operations, including all assets supporting a particular operation regardless of how close, or far, from the shore they may be operating.

3.2.2 Active Sonar System Components

The active sonar component of the SURTASS LFA sonar system, LFA sonar, is an adjunct to the SURTASS passive capability and is employed when active sound signals are needed to detect and track underwater targets. The characteristics and operating features of the active component of LFA sonar are:

- The sonar source is a vertical line array (VLA) of up to 18 source projectors suspended beneath the vessel. LFA's transmitted sonar beam is omnidirectional (360 degrees) in the horizontal, with a narrow vertical beamwidth that can be steered above or below the horizontal.
- The source frequency is between 100 and 500 Hz.
- The SL of an individual source projector of the SURTASS LFA sonar array is approximately 215 dB re 1 µPa (rms) at 1m or less. As measured by sound pressure level, the sound field of the array can never be higher than the SL of an individual source projector.
- The typical LFA sonar signal is not a constant tone but is a transmission of waveforms that vary in frequency and duration. A complete sequence of sound transmissions is referred to as a wavetrain (also known as a "ping"). These wavetrains last between 6 and 100 seconds with an average length of 60 seconds. Within each wavetrain, a variety of signal types can be used, including continuous wave (CW) and frequency-modulated (FM) signals. The duration of each continuous frequency sound transmission is no longer than 10 seconds.
- The maximum duty cycle (ratio of sound "on" time to total time) is 20 percent. The typical duty cycle, based on SURTASS LFA data from 2003 to 2018, is 7.5 to 10 percent.
- The time between wavetrain transmissions is typically 6 to 15 minutes (min).

LFA sonar complements SURTASS passive activities by actively acquiring and tracking submarines when they are in quiet operating modes, measuring accurate target range, and re-acquiring lost contacts.

3.3 Vessel Specifications

As stated in Section 3.1, the Navy currently has four surveillance ships that are equipped with SURTASS LFA sonar systems: USNS VICTORIOUS (Tactical-Auxiliary General Ocean Surveillance [T-AGOS] 19); USNS ABLE (T-AGOS 20); USNS EFFECTIVE (T-AGOS 21); and USNS IMPECCABLE (T-AGOS 23). The USNS *ABLE*, USNS *EFFECTIVE*, and USNS *VICTORIOUS* are twin-hulled ocean surveillance ships. These three vessels each vessel have a length of 71.6 m (235 ft), a beam of 28.5 m (93.6 ft), a maximum draft of 7.6 m (25 ft), a full load displacement of 3,451 metric tons (3,396 tons), and a twin-shaft diesel electric engine that provides 3,200 horsepower, which drives two propellers. These ships may travel at top speeds of 10 kt (18.5 kph) when not towing the SURTASS LFA sonar arrays. The USNS *IMPECCABLE*, is also a twin-hulled ocean surveillance ship. It has a length of 85.8 m (281.5 ft), a beam of 29.2

m (95.8 ft), a maximum draft of 7.9 m (26 ft), a full load displacement of 5,454 metric tons (5,368 tons), and a twin shaft diesel electric engine that provides 5,000 horsepower, which drives two propellers. The USNS IMPECCABLE has a top speed of 12 kt (22 kph) when not towing the SURTASS LFA sonar arrays. The operational speed of all four vessels during SURTASS LFA sonar training and testing activities will be approximately 5.6 kph (3 kt), and each vessel's cruising speed outside of SURTASS LFA sonar training and testing activities would be a maximum of approximately 18.5 to 24.1 kph (10 to 13 kt). The Navy may develop and field additional SURTASS LFA sonar equipped vessels, either to replace or complement the Navy's current SURTASS LFA sonar-capable fleet.

3.4 Mitigation and Monitoring

Mitigation is an action that avoids or reduces the severity of the effects of the action on ESA-listed species. Under the MMPA, NMFS must prescribe how the Navy is to effect the least practicable adverse impact on marine mammal species or stocks and their habitat as we as monitoring requirements. Through the ESA, NMFS' incidental take statement must include reasonable and prudent measures to minimize the impact of the taking and terms and conditions to implement those measures to reduce the likelihood of adverse effects to ESA-listed marine species or adverse effects to their designated critical habitats. Monitoring is used to observe or check the progress of the mitigation over time.

Through the course of previous SURTASS LFA sonar section 7 consultations and MMPA rule making, NMFS has worked with the Navy to identify and implement various mitigation and monitoring activities. Under the terms and conditions of the current and past biological opinions and incidental take statements, the Navy was required to carry out all mitigation and monitoring requirements contained in the five-year regulations and annual letters of authorization issued under section 101(a)(5)(A) of the MMPA. Summaries of the results of these requirements are documented in quarterly, annual, and comprehensive reports.

The bulleted items listed below are mitigation and monitoring measures incorporated by the Navy in its proposed action for this consultation. Although they are described in the Navy's proposed action section in this opinion, these measures are at least partly the result of the ESA section 7 consultation process and the MMPA rule making which includes a public comment process. These measures are required when SURTASS LFA sonar is transmitting to reduce the potential for injury or harassment to marine mammals and sea turtles. The Navy implements the mitigation and monitoring measures listed below. Additional detail for each mitigation and monitoring measure is described in subsequent sections of this opinion:

- Operational Parameters
- Mitigation and buffer zone
- Ramp Up of HF/M3
- LFA Sonar Suspension/Delay
- Geographic Mitigation Measures

- Coastal Standoff Distance
- Dive Sites
- Offshore Biologically Important Areas
- Sound Field Monitoring
- Visual Monitoring
- Passive Acoustic Monitoring
- Active acoustic monitoring – high frequency/marine mammal monitoring sonar

3.4.1 Operational Parameters

The sound signals transmitted by the SURTASS LFA sonar source would be maintained between 100 and 500 Hz with a SL for each of the 18 projectors of no more than 215 dB re 1 µPa (rms) and a maximum duty cycle of 20 percent. The Navy is currently approved under the NDE to transmit 1,020 hours of LFA sonar transmission hours per year (Navy 2017c). In this proposed action, the Navy is proposing to reduce the annual number of transmit hours to 496 hours of SURTASS LFA sonar transmissions in years 1 to 4 and 592 hours in years 5 to 7.

3.4.2 Mitigation/Buffer Zone

In previous applications for rulemaking for SURTASS LFA sonar, the Navy proposed a mitigation zone covering a volume of water ensonified to the 180 dB re 1 µPa (rms) isopleth (i.e., the volume subjected to sound pressure level of 180 dB rms or greater), and noted that the nominal outer boundary of this volume of water is approximately 1 km (0.54 nmi). In each of the resultant Final Rules, NMFS added a 1-km buffer zone beyond the Navy's proposed LFA sonar mitigation zone, so the total resulting mitigation/buffer zone was nominally 2 km (1.08 nmi).

Navy requested, and NMFS' Permits and Conservation Division agreed, to establish a single, fixed, combined mitigation/buffer zone of 2,000 yards (yd) (0.99 nmi) (1,829 m/1.83 km) rather than a combined mitigation/buffer zone of nominally 1.08 nmi (2 km). This 2,000 yd (1.83 km) single fixed mitigation/buffer zone would cover virtually all of the previous combined mitigation/buffer zone of nominally 1.08 nmi (2 km), since the difference between 2,000 yd and 2 km is only about 187 yd (or 0.09 nmi [167 m]). Likewise, the difference in the sound field of the combined mitigation/buffer zones of 2,000 yd (1.83 km) versus 1.08 nmi (2,187 yd; 2 km) would also be negligible in this case. At 2,000 yd (1.83 km), modeling shows that the sound field would be about 174.75 dB while at 1.08 nmi (2 km), the sound file would be 173.98 dB, which is a difference of only 0.77 dB. This very slight sound field difference is unlikely to be a perceptible change to a marine mammal or sea turtle in this instance. Establishing a single fixed combined mitigation/buffer zone for SURTASS LFA sonar training and testing activities will standardize and thus simplify implementation of the monitoring requirement, including a buffer zone, using more standard Navy metrics (yards, not meters), while continuing to ensure protection to marine mammals in all acoustic environments, even in the rare event of a strong acoustic duct in which the volume of water ensonified to 180 dB could be somewhat greater than

1 km (DoN, 2001). With the combined mitigation/buffer zone of 2,000 yd, there is no potential for animals to be exposed to received levels greater than 180 dB rms.

3.4.3 Ramp Up of High Frequency Marine Mammal Monitoring (HF/M3)

As stated earlier, and described in detail below in Section 3.4.12, the Navy will use a High Frequency Marine Mammal Monitoring (HF/M3) system to monitor for marine mammals. The Navy intends to implement a ramp-up procedure for the HF/M3 sonar system to ensure that no inadvertent exposures of marine animals to received levels (RLs) ≥180 dB re 1 µPa (rms) would occur if an animal were to occur near the transmitting HF/M3 sonar system. Prior to full-power transmissions, the HF/M3 sonar power level would be ramped up over a period of no less than 5 minutes from a SL of 180 dB re 1 µPa (rms) @ 1 m in 10 dB increments until full power (if required) is attained. This ramp-up procedure would commence at least 30 minutes prior to initiation of any SURTASS LFA sonar transmissions during testing and training activities, prior to any sonar calibrations or testing that are not part of the regularly planned transmissions, and any time after the HF/M3 sonar has been powered down for more than two minutes. The HF/M3 active sonar system's sound pressure level may not increase once a marine mammal or sea turtle is detected. The ramp-up process of HF/M3 may resume only if no additional marine animals are detected by the HF/M3 active sonar system, passive acoustic monitoring, or visual monitoring.

3.4.4 Low Frequency Active Sonar Suspension/Delay

During training and testing activities, SURTASS LFA sonar transmissions would be delayed or suspended only if a marine mammal or sea turtle is detected by visual, passive acoustic, or active acoustic monitoring entering or already located within the LFA mitigation/buffer zone. When a sea turtle or marine mammal is detected within the LFA mitigation/buffer zone, the senior military member-in-charge would order the immediate suspension of LFA sonar transmissions. During the delay/suspension of LFA sonar transmissions, active acoustic, visual, and passive acoustic monitoring for marine mammals and sea turtles would continue. LFA sonar transmissions would be allowed to commence/resume no sooner than 15 minutes after marine mammals/sea turtles are no longer detected within the LFA mitigation/buffer zone.

If a marine mammal or sea turtle is detected outside the LFA mitigation/buffer zone but is thought to be closing on the LFA mitigation/buffer zone, the range and projected track (bearing) of the detected animal is determined and reported to the senior military member-in-charge, but LFA sonar is not yet suspended/delayed. The position of the detected marine animal is closely monitored for intersection with the LFA mitigation/buffer zone. When the marine animal enters the LFA mitigation/buffer zone, then LFA training and testing sonar transmissions would be suspended or delayed.

3.4.5 Geographical Mitigation Measures

Based on the analyses presented in NEPA documents for SURTASS LFA sonar (Navy 2001a; Navy 2001b; Navy 2007; Navy 2012; Navy 2017b), geographic restrictions for the use of

SURTASS LFA sonar have been developed to provide the lowest practicable risk to marine mammals.The Navy intends to apply the following geographic mitigation measures during SURTASS LFA sonar training and testing activities:

- SURTASS LFA sonar training and testing activities would not occur within the territorial seas of foreign nations;
- SURTASS LFA sonar-generated sound field below RLs of 180 dB re 1 µPa (rms) within 12 nmi (22 km) of any emergent land (including islands);
- SURTASS LFA sonar-generated sound field below RLs of 180 dB re 1 µPa (rms) at a distance of 1 km from the outer boundary of OBIAs during biologically important periods that have been determined by NMFS and the Navy;[8]
- No more than 25 percent of the authorized amount of SURTASS LFA sonar would be used for training and testing activities within 10 nmi (18.5 km) of any single OBIA during any year unless the following condition is met: should national security present a requirement to conduct more than 25 percent of the authorized hours of SURTAS LFA sonar within 10 nmi (18.5 km) of any single OBIA during any year, naval units would obtain permission from the appropriate designated Command authority prior to commencement of the activity. The Navy would provide NMFS with notification as soon as is practicable and include the information (e.g., sonar hours) in its annual activity reports submitted to NMFS.
- SURTASS LFA sonar RLs ≥ 145 dB re 1 µPa (rms) would not occur at known recreational or commercial dive sites unless the following conditions are met: should national security present a requirement to transmit SURTASS LFA sonar during training or testing activities such that exposure at known recreational or commercial dive may exceed RLs equal to 145 dB re 1 µPa (rms), naval units would obtain permission from the appropriate designated Command authority prior to commencement of the activity. Prior to conducting the training or testing activity, the designated Command authority shall conduct a risk assessment, taking into account the potential for exposure of SURTASS LFA sonar to divers;
- SURTASS LFA sonar would not be used in the waters over Penguin Bank, Hawaii, to the extent of the 600 ft (183 m) depth contour; and
- SURTASS LFA sonar operators would estimate LFA sound field RLs (sound pressure levels) prior to and during active SURTASS LFA sonar training and testing activities so that the distance from the LFA sonar system to the 180 dB re 1 µPa (rms) and 145 dB re 1 µPa (rms) isopleths are known. However, if NMFS imposes a buffer zone and implements the requested fixed, single, combined mitigation/buffer zone of 2,000 yd (1.8 km), then sound field modeling to define the mitigation zone would not be necessary because the volume of water ensonified to 180 dB would be subsumed in the fixed, single combined mitigation/buffer zone of 2,000 yd (1.8 km). Accordingly, sound field modeling to

[8] In past authorizations for SURTASS LFA sonar, NMFS has required a 0.54 nmi (1-km) buffer zone on the seaward boundary of OBIAs in which the sound field generated by LFA sonar would be below RLs of 180 dB re 1 µPa (rms); this requirement is maintained.

estimate the distance to the 180-dB isopleth would not be conducted as it would be unnecessary.

3.4.6 Coastal Standoff Distance

Since most areas of biological importance to ESA-listed and MMPA protected species are in coastal waters, the Navy first established the policy of the coastal standoff range, in which waters within 12 nmi (22 km) of any emergent land would not be ensonified with SURTASS LFA sonar at levels at or above 180 dB re 1 µPa (rms). This distance and sound field measure were established to lower the risk to marine mammals and especially sea turtles, which aggregate in coastal waters. The Navy would continue to implement the 12 nmi (22 km) coastal standoff range while using SURTASS LFA sonar for training and testing activities. In addition, the Navy would not conduct SURTASS LFA sonar training and testing activities within foreign nations' territorial seas.

3.4.7 Dive Sites

During training and testing activities, SURTASS LFA sonar transmissions near known recreational dive sites would be transmitted such that the sound field at such sites does not exceed RLs of 145 dB re 1 µPa (rms). Although recreational dive sites are generally located in coastal/island areas in waters from the shoreline out to a water depth of about 130 ft (40 m), the Navy recognizes that other dive sites may be outside this boundary.

3.4.8 Offshore Biologically Important Areas (OBIAs)

Since certain areas of biological importance to ESA-listed and MMPA protected marine mammals lie outside the coastal standoff range and given the unique transmission characteristics of SURTASS LFA sonar, the Navy and NMFS developed the concept of marine mammal OBIAs for SURTASS LFA sonar as part of the Navy's first NEPA documentation for SURTASS LFA sonar (Navy 2001b). OBIAs are part of a comprehensive suite of mitigation measures used in previous authorizations to minimize adverse impacts to marine mammal populations.

Associated with each OBIA is an effective period during which marine mammals, including ESA-listed species, carry out biologically significant activities. During that time period, SURTASS LFA sonar cannot be transmitted at RLs of greater than 180 dB re 1 µPa (rms) within 1 km seaward of any OBIA boundary. In addition, no more than 25 percent of the authorized amount of SURTASS LFA sonar would be used for training and testing activities within 10 nmi (18.5 km) of any single OBIA during any year unless the following condition is met: should national security present a requirement to conduct more than 25 percent of the authorized hours of SURTAS LFA sonar within 10 nmi (18.5 km) of any single OBIA during any year, naval units would obtain permission from the appropriate designated Command authority prior to commencement of the activity. The Navy would provide NMFS with notification as soon as is practicable and include the information (e.g., sonar hours) in its annual activity reports submitted to NMFS. The 2017 NDE for SURTASS LFA designated 29 marine mammal OBIAs and their effective periods as geographic mitigation with which the Navy must comply for SURTASS

LFA sonar activities. These OBIAs resulted from analyses conducted as part of the 2017 SEIS/SOEIS and application for rulemaking, and retained existing OBIAs; revised/expanded existing OBIAs; and added new OBIAs to those defined as part of the 2012 SURTASS LFA sonar rule (Navy 2017b). Of these 29 OBIAs, four are located within the proposed SURTASS LFA sonar action area (OBIA 16, Penguin Bank, Hawaiian Islands Humpback Whale NMS; OBIA 20, Northern Bay of Bengal and Head of Swatch-of-No-Ground; OBIA 26, Offshore Sri Lanka; and OBIA 27, Camden Sound/Kimberly Region), as indicated in Table 5, below.

Table 5. Marine Mammal OBIAs Currently Located in the SURTASS LFA Sonar Action Area.

OBIA Number	*Name of OBIA*	*Location/Water Body*	*Relevant Low-Frequency Marine Mammal Species*	*Effectiveness Seasonal Period*
16	Penguin Bank, Hawaiian Islands Humpback Whale NMS	North-Central Pacific Ocean	Humpback whale	November through April, annually
20	Northern Bay of Bengal and Head of Swatch-of-No-Ground (SoNG)	Bay of Bengal/Northern Indian Ocean	Bryde's whale	Year-round
26	Offshore Sri Lanka	North-Central Indian Ocean	Blue whale	December through April, annually
27	Camden Sound/Kimberly Region	Southeast Indian Ocean; northwestern Australia	Humpback whale	June through September, annually

Since the 2017 SEIS/SOEIS and NDE for SURTASS LFA sonar, analysis and assessment of marine areas as potential OBIAs has continued. For the current proposed MMPA rule for SURTASS LFA sonar training and testing activities, NMFS' Permits and Conservation Division applied biological, geographic, and hearing sensitivity factors, as well as practicability criterion, and are considering only areas within the action area (central and western North Pacific and eastern Indian Oceans). For more information on the OBIA selection factors, please see NMFS (2019) and Navy (2019).

A total of 40 different types of marine areas were assessed as potential marine mammal OBIAs for SURTASS LFA sonar (See Appendix C, Table C-2 of Navy 2019). Although 40 marine areas were considered, some types of marine areas were combined if they were designated for the same geographic area or if they were recommended for different species of marine mammals.

Of the 33 marine areas thoroughly assessed as OBIAs, the Navy and NMFS's assessment resulted in 14 candidate OBIAs being designated for 17 of the marine areas (See Table 6 below), pending Navy Fleet review for practicability. Some OBIAs, such as the blue and humpback whale OBIAs for Western Australia encompassed several marine areas, which is why the number of candidate OBIAs is less than the number of marine areas for which OBIAs were designated. Table 7 below shows a list of the 14 candidate OBIAs for 17 of the marine areas, pending Navy Fleet review for practicability.

Table 6. Marine Areas for Further Consideration as Marine Mammal Offshore Biologically Important Areas (OBIAs) for SURTASS LFA Sonar.

Marine Area Number	***Marine Area Name***	***Ocean Area***	***Effective Seasonal Period***	***Candidate OBIA Name***
Candidate OBIAs: Marine Areas Meeting OBIA Designation Criteria				
1	Main Hawaiian Archipelago	Central North Pacific Ocean	November to April	Main Hawaiian Islands
2	Papahānaumokuākea Marine National Monument	Central North Pacific Ocean	December to April	Northwestern Hawaiian Islands
3	Northwestern Hawaiian Islands	Central North Pacific Ocean		
4	Marianas Trench Marine National Monument	Western North Pacific Ocean	February to April	Marianas
5	Bluefin Spawning/Babuyan Marine Corridor	Western North Pacific Ocean	January to April	Ryukyu-Philippines
6	Ogasawara Islands	Western North Pacific Ocean	June to September	Ogasawara (sperm whales),
			December to May	Ogasawara-Kazin (humpbacks)
7	Convection Zone East of Honshu	Western North Pacific Ocean	January to May	Honshu
8	Southeast Kamchatka Coastal Waters	Western North Pacific Ocean	June to September	Southeast Kamchatka
9	Upper Gulf of Thailand/Bay of Bangkok	Eastern Indian Ocean	April to November	Gulf of Thailand
10	Savu Sea and Surrounding Areas	Eastern Indian Ocean	May to November	Western Australia (blue whales)
11	North Western Australia Shelf/Ningaloo Reef	Eastern Indian Ocean	May to November May to December	Western Australia (blue whales) Western Australia (humpback whales)
12	Western Australia (Shark Bay to Exmouth Gulf)	Eastern Indian Ocean	May to December	Western Australia (humpback whales)

Marine Area Number	***Marine Area Name***	***Ocean Area***	***Effective Seasonal Period***	***Candidate OBIA Name***
13	Browse Basin	Eastern Indian Ocean	May to November	Western Australia (blue whales)
14	Southern Bali Peninsula and Slope	Eastern Indian Ocean	October to November	Southern Bali
15	Swatch-of-No-Ground (SoNG)	Northern Bay of Bengal	Year-round	SoNG
16	Trincomalee Canyon and Associated Ecosystems	Eastern Indian Ocean	October to April	Sri Lanka
17	Southern Coastal/Offshore Waters between Galle and Yala National Park	Eastern Indian Ocean		
Marine Areas Not Further Considered for OBIAs				
18	Hawaiian Monk Seal Critical Habitat	Central North Pacific Ocean		
19	Main Hawaiian Island Insular DPS of False Killer Whale Critical Habitat	Central North Pacific Ocean		
20	Pacific Remote Islands Marine National Monument (Only Wake/ Johnson/Palmyra atolls and Kingman Reef Units)	Western and Central North Pacific Ocean		
21	Kyushu Palau Ridge	Western North Pacific Ocean		
22	Raja Ampat and Northern Bird’s Head	Western North Pacific Ocean		
23	North Pacific Transition Zone	Western North Pacific Ocean		
24	Polar/Kuroshio Extension Fronts	Western North Pacific Ocean		
25	Kuroshio Current South of Honshu	Western North Pacific Ocean		

Marine Area Number	*Marine Area Name*	*Ocean Area*	*Effective Seasonal Period*	*Candidate OBIA Name*
26	Peter the Great Bay	Western North Pacific Ocean		
27	Moneron Island Shelf	Western North Pacific Ocean		
28	Kien Giang and Kep Archipelago	Southeast Asian Seas		
29	Southern Andaman Islands	Northeastern Indian Ocean		
30	Gulf of Mannar and Palk Bay	North Indian Ocean		
31	Lakshadweep Archipelago	Central Indian Ocean		
32	West and South Coasts of India	Central Indian Ocean		
33	West of Maldives	Central Indian Ocean		

Table 7. Marine Mammal Offshore Biologically Important Areas (OBIAs) Newly Designated in the Study Area for SURTASS LFA Sonar.

Candidate OBIA Number	*OBIA Name*	*Ocean Area*	*Relevant Low-Frequency Marine Mammal Species*	*Effective Seasonal Period*	*Notes*
1	Main Hawaiian Islands	Central North Pacific	Humpback whale	November to April	Expansion of existing OBIA #16, Penguin Bank
2	Northwestern Hawaiian Islands	Central North Pacific	Humpback whale	December to April	
3	Marianas Islands	Western North Pacific	Humpback whale	February to April	
4	Ryukyu-Philippines	Western North Pacific	Humpback whale	January to April	

5	Ogasawara Islands (Sperm Whale)	Western North Pacific	Sperm whale	June to September	
6	Ogasawara-Kazin Islands (Humpback Whale)	Western North Pacific	Humpback whale	December to May	
7	Honshu	Western North Pacific	Gray whale	January to May	
8	Southeast Kamchatka	Western North Pacific	Humpback, fin, Western North Pacific gray, and North Pacific right whales	June to September	
9	Gulf of Thailand	Eastern Indian Ocean	Bryde's whale	April to November	
10	Western Australia (Blue Whale)	Eastern Indian Ocean	Blue (pygmy) whale	May to November	
11	Western Australia (Humpback Whale)	Eastern Indian Ocean	Humpback whale	May to December	Expansion of existing OBIA #27, Kimberly-Camden Sound
12	Southern Bali	Eastern Indian Ocean	Bryde's, sei, humpback, Omura's, and sperm whales	October to November	
13	Swatch-of-No-Ground (SoNG)	Northern Bay of Bengal	Bryde's whale	Year-round	Expansion of existing OBIA #20, Northern Bay of Bengal/SoNG
14	Sri Lanka	Eastern Indian Ocean	Blue (pygmy) and sperm whales	October to April	Expansion of existing OBIA #26, Offshore Sri Lanka

3.4.9 Sound Field Modeling

The SURTASS LFA sonar crew would estimate SURTASS LFA sonar sound field RLs prior to and during training and testing sonar transmissions to provide the information necessary to modify transmissions, including the delay or suspension of transmissions, so that the sound field criteria are not exceeded. If NMFS imposes a buffer zone and implements the requested fixed, single, combined mitigation/buffer zone of 2,000 yd (1.83 km), then sound field modeling to determine the mitigation shutdown range to the 180 dB re 1 µPa (rms) isopleth would not be necessary and would not be conducted. Sound field limits would be estimated using near real-time environmental data and underwater acoustic performance prediction models. These models are an integral part of the SURTASS LFA sonar processing system. Acoustic model updates would nominally be made every 12 hours or more frequently, depending upon the variance in meteorological or oceanographic conditions.

3.4.10 Visual Monitoring

Visual monitoring would include daytime observations of the sea surface for the presence of marine mammals and sea turtles from the bridge of SURTASS LFA sonar vessels. Daytime is defined as the time beginning 30 minutes before sunrise and ending 30 minutes after sunset. Visual monitoring would begin 30 minutes before sunrise or 30 minutes before SURTASS LFA sonar begins to transmit and would continue until 30 minutes after sunset or until the SURTASS LFA sonar training and testing transmissions cease. Observations would be made by civilian ship personnel trained in detecting and identifying marine mammals and sea turtles from the ship's bridge using standard binoculars (7x) and the naked eye. The objective of visual monitoring would be to ensure that no marine mammal or sea turtle approaches the ship or transmitting sonar array close enough to enter the LFA mitigation/buffer zone.

Visual observers would maintain a watch for marine mammals and sea turtles at the sea surface and log all detections of marine animals during SURTASS LFA sonar training and testing transmissions. The number, identification, bearing, and range of observed marine mammals or sea turtles, as well as any unusual behavior they may exhibit, would be recorded. A designated ship's officer would monitor the conduct of the visual watches and would periodically review the observation log. If a potentially affected marine mammal or sea turtle would be sighted anywhere within the LFA mitigation/buffer zone, the bridge officer would notify the senior military member-in-charge of the military crew (MILCREW) onboard the SURTASS LFA sonar vessel who would order the immediate delay or suspension of SURTASS LFA sonar transmissions. Similarly, if a marine mammal or sea turtle were sighted outside the LFA mitigation/buffer zone, the bridge officer would notify the senior military member-in-charge of the estimated range and bearing of the observed marine mammal or sea turtle. The senior military member-in-charge would notify the HF/M3 sonar operator to verify or determine the range and projected track of the detected marine mammal or sea turtle. If the sonar operator

determines that the marine mammal or sea turtle would pass into the LFA mitigation/buffer zone, the senior military member-in-charge would order the immediate delay or suspension of SURTASS LFA sonar transmissions when the marine animal enters the LFA mitigation/buffer zone. The visual observer would continue visual observations until the marine mammal or sea turtle is no longer observed. SURTASS LFA sonar transmissions would commence/resume 15 minutes after there would be no further detection of marine mammals or sea turtles by visual, active acoustic (HF/M3 sonar), or passive acoustic monitoring within the LFA mitigation/buffer zone. If a detected marine mammal were exhibiting unusual behavior, visual monitoring of the detected animal would continue until the behavior returns to normal or conditions did not allow monitoring to continue.

3.4.11 Passive Acoustic Monitoring

Passive acoustic monitoring would be conducted using the SURTASS towed HLA to listen for (detect) vocalizing marine mammals as an indicator of their presence whenever LFA sonar is transmitting during training and testing activities. If a detected sound were estimated to be from a vocalizing marine mammal, the sonar technician would notify the senior military member-in-charge, who would alert the HF/M3 sonar operator and visual observers (during daylight). Delay or suspension of SURTASS LFA sonar transmissions would be ordered when the HF/M3 sonar and/or visual observers verify the presence of a marine mammal to be within the LFA mitigation/buffer zone. Passive acoustic sonar technicians are trained to identify the detected vocalizations to marine mammal species whenever possible. Passive acoustic monitoring would begin 30 minutes prior to the first LFA sonar transmission, continue throughout all LFA sonar transmissions, and cease 15 minutes after LFA sonar transmissions have concluded.

3.4.12 Active Acoustic Monitoring

HF active acoustic monitoring uses the HF/M3 sonar to detect, locate, and track marine mammals (and possibly sea turtles and large fish) that could pass close enough to the SURTASS LFA sonar array to enter the LFA mitigation/buffer zone. HF/M3 sonar monitoring would begin 30 minutes before the first SURTASS LFA sonar transmission is scheduled to commence and continue until 15 minutes after LFA sonar transmissions are terminated. Prior to full-power use, the HF/M3 sonar power level would be ramped up over a period of 5 minutes from the SL of dB re 1 µPa (rms) @ 1 m in 10 dB increments until full power (if required) would be attained to ensure that there are no inadvertent exposures of marine mammals or sea turtles to RLs ≥180 dB re 1 µPa (rms) from the HF/M3 sonar.

If a contact were detected during HF/M3 monitoring within the LFA mitigation/buffer zone, the sonar operator would notify the senior military member in charge, who would order the immediate delay or suspension of LFA sonar transmissions. Likewise, if HF/M3 monitoring were to detect a possible marine mammal or sea turtle outside the LFA mitigation/buffer zone, the HF/M3 sonar operator would determine the range and projected track of the marine mammal or sea turtle and notify the senior military member in charge that a detected animal would pass

within the LFA mitigation/buffer zone. The senior military member in charge would notify the bridge and passive sonar operator of the potential presence of a marine animal projected to enter the mitigation zone. The senior military member in charge would order the delay or suspension of LFA sonar transmissions when the marine mammal/sea turtle would be predicted to enter the LFA mitigation/buffer zone. SURTASS LFA sonar transmissions would commence/resume 15 minutes after there are no further detections by the HF/M3 sonar, visual, or passive acoustic within the LFA mitigation/buffer zone.

The effectiveness of the HF/M3 sonar system to monitor and detect marine mammals has been described in the Navy's 2001 FOEIS/EIS (Chapters 2 and 4) for SURTASS LFA sonar (DoN, 2001) in addition to the technical report by (Stein and Ellison 2001). To summarize the effectiveness of the HF/M3 sonar system, the Navy's testing and analysis of the HF/M3 sonar system's capabilities indicated that the system:

- substantially increased the probability of detecting a marine mammal within the LFA mitigation/buffer zone;
- provides a superior monitoring capability, especially for medium- to large-sized marine mammals to a distance of 1.1 to 1.3 nmi (2 to 2.5 km) from the system (DoN, 2001);
- would result in several detections of a marine mammal before it even entered the LFA mitigation/buffer zone (DoN, 2001). Indeed, based on the scan rate of the HF/M3 sonar system, most animals would receive at least eight pings from the sonar (i.e., eight sonar returns or detections) before even entering the LFA mitigation/buffer zone.
    - the probability of the HF/M3 sonar system detecting a medium- to large-sized (~33 to 98 ft [10 to 30 m]) marine mammal (humpback to blue whale) swimming towards the system in the LFA mitigation/buffer zone with only one HF/M3 ping would be near 100 percent (Stein and Ellison 2001);
    - for small (~8 ft [2.5 m]) marine mammals such as a dolphin, the detection is 55 percent from one HF/M3 ping when the sonar is located at a distance of 2,625 to 3,051 ft (800 to 930 m) from the animal, while the detection probability increases to 90 percent for four HF/M3 pings; and
- may result in higher detection probabilities in a typical at-sea environment—during HF/M3 testing, analysts noted that in the expected at-sea conditions of reduced clutter interference in the open ocean and small marine mammals traveling in their typical group configurations (i.e., in pods), the detection rate would be higher (Stein and Ellison 2001).

Qualitative and quantitative assessments of the HF/M3 system's ability to detect marine mammals of various sizes were verified by 170 hours of at-sea testing (Stein and Ellison 2001). Since the information on the HF/M3 sonar system remains valid, it is thus incorporated herein by reference.

3.5 NMFS Permits and Conservation Division Proposed Actions

NMFS is the federal agency largely responsible for the stewardship of the nation's living marine resources and their habitat and administering the MMPA. The MMPA was enacted by Congress in 1972 due to issues concerning the well-being of marine mammals, which prompted Congress to take action. Provisions in the MMPA reflect two major conservation principles: preservation and resource management. The concept of preservation is reflected in the MMPA's prohibition on the "taking" and importation of marine mammals. Under the MMPA, "take" means to harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill any marine mammal. Due to the compelling interest in promoting the preservation of marine mammals throughout their range, these provisions apply to "any person," including the Federal government. The concept of resource management is reflected in the MMPA's exceptions to the taking prohibition and also in the authority of the Secretary of Commerce to authorize takings of marine mammals provided that certain standards are met.

Section 101(a) of the MMPA (16 U.S.C. §1372) generally prohibits the "take" of marine mammals by U.S. citizens or by any person or vessel in waters under U.S. jurisdiction (including the U.S. Gulf of Mexico), subject to certain exceptions. Among the enumerated exceptions to the take prohibition is take that is authorized under an incidental take authorization issued under either section 101(a)(5)(A) or (D) of the MMPA (16 U.S.C. §1371 (a)(5)). Authorization for incidental takings are granted if:

- NMFS finds that the taking will have a negligible impact on the species or stock(s);
- NMFS finds that the taking will not have an unmitigable adverse impact on the availability of the species or stock(s) for subsistence uses (where relevant); and
- NMFS sets forth the permissible methods of taking and requirements pertaining to the mitigation, monitoring, and reporting of such takings.

NMFS Permits and Conservation Division proposes two interrelated actions. First, it proposes to promulgate regulations governing incidental take from Navy SURTASS LFA sonar training and testing activities pursuant to MMPA section 101(a)(5)(A). The MMPA regulations establish a framework that will allow NMFS Permits and Conservation Division to issue letters of authorization governing taking of marine mammals incidental to SURTASS LFA sonar training and testing activities.

3.5.1 Promulgation of Regulations Pursuant to the Marine Mammal Protection Act

NMFS Permits and Conservation Division will promulgate Federal regulations under the MMPA for Navy SURTASS LFA sonar training and testing activities. The process to create Federal MMPA regulations is briefly described below.

In order for NMFS Permits and Conservation Division to consider authorizing the taking by U.S. citizens of "small numbers" of marine mammals in a specified geographic region incidental to a specified activity (other than commercial fishing), or to make a finding that an incidental take is

unlikely to occur, a written request must be submitted to NMFS. NMFS Permits and Conservation Division will then determine the adequacy and completeness of a request and, if determined to be adequate and complete, will begin the public review process by publishing in the *Federal Register* a notice of receipt of a request for the implementation of regulations governing the incidental taking. Through notice in the *Federal Register*, NMFS invites information, suggestions, and comments for a period not to exceed 30 days from the date of publication in the *Federal Register*. All information and suggestions are considered by NMFS Permits and Conservation Division in developing, if appropriate, the most effective regulations governing the issuance of letters of authorization. NMFS Permits and Conservation Division evaluates each request based on the best available scientific evidence. Any preliminary findings of "negligible impact" and "no unmitigable adverse impact" will be proposed for public comment along with the proposed regulations for the specific activity. If, subsequent to the public review period, NMFS Permits and Conservation Division finds that the taking by the specified activity would have more than a negligible impact on the species or stock of marine mammal or would have an unmitigable adverse impact on the availability of such species or stock for subsistence uses, NMFS will publish in the *Federal Register* the negative finding along with the basis for denying the request. As new information is developed, through monitoring, reporting, or research, the regulations may be modified, in whole or in part, after notice and opportunity for public review.

The NDAA of 2004 (Public Law 108-36) modified the MMPA by removing the "small numbers" and "specified geographic region" limitations and amended the definition of "harassment" as it applies to a "military readiness activity" to read as follows (Section 3(18)(B) of the MMPA): "(i) any act that injures or has the significant potential to injure a marine mammal or marine mammal stock in the wild (Level A harassment); or (ii) any act that disturbs or is likely to disturb a marine mammal or marine mammal stock in the wild by causing disruption of natural behavioral patterns, including, but not limited to, migration, surfacing, nursing, breeding, feeding, or behavioral patterns are abandoned, or significantly altered (Level B harassment)." The Navy's SURTASS LFA sonar training and testing activities are considered a "military readiness activity."

3.5.1.1 *Taking and Importing Marine Mammals; Navy Training and Testing of Surveillance Towed Array Sensor System Low Frequency Active Sonar*

A subset of the proposed MMPA regulations governing the incidental take of marine mammals during Navy training and testing of SURTASS LFA sonar is presented below. We focused on those aspects of the proposed regulations that may affect ESA-listed species or their designated critical habitat.

Mitigation (§218.234)

When conducting activities identified in § 218.230, the mitigation measures described in this section and in any LOA issued under §§ 216.106 of this chapter and 218.237 must be implemented.

(a) Personnel training - Lookouts: The Navy will utilize one or more trained marine biologists qualified in conducting at-sea marine mammal visual monitoring to conduct at-sea marine mammal visual monitoring training and qualify designated ship personnel to conduct at-sea visual monitoring. Training will ensure quick and effective communication within the command structure in order to facilitate implementation of protective measures if they detect marine mammals and may be accomplished either in-person, or via video training.

(b) General operating procedures:

(1) Prior to SURTASS LFA sonar activities, the Navy will promulgate executive guidance for the administration, execution, and compliance with the environmental regulations under these regulations and LOA.

(2) The Navy must not transmit the SURTASS LFA sonar signal at a frequency greater than 500 Hz.

(c) 2,000 yd LFA sonar mitigation/buffer zone; Suspension and Delay. If a marine mammal is detected, through monitoring required under § 218.235, within or about to enter within 2,000 yd of the SURTASS LFA source (i.e., the LFA mitigation/buffer zone), the Navy must immediately delay or suspend SURTASS LFA sonar transmissions.

(d) Resumption of SURTASS LFA sonar transmissions.

(1) The Holder of a LOA may not resume SURTASS LFA sonar transmissions earlier than 15 minutes after:

(i) All marine mammals have left the area of the 2,000 yd LFA sonar mitigation zone; and

(ii) There is no further detection of any marine mammal within the 2,000 yd LFA sonar mitigation zone as determined by the visual, passive, and active acoustic high frequency monitoring described in § 218.235.

(2) [Reserved]

(e) Ramp-up procedures for the high-frequency marine mammal monitoring (HF/M3) sonar required under § 218.235.

(1) The Navy must ramp up the HF/M3 sonar power level beginning at a maximum source sound pressure level of 180 dB: re 1 μPa at 1 m in 10-dB increments to operating levels over a period of no less than five minutes:

(i) At least 30 minutes prior to any SURTASS LFA sonar transmissions; and

(ii) Anytime after the HF/M3 source has been powered down for more than two minutes.

(2) The Navy must not increase the HF/M3 sound pressure level once a marine mammal is detected; ramp-up may resume once marine mammals are no longer detected.

(f) Geographic restrictions on the SURTASS LFA sonar sound field.

(1) LFA sonar training and testing activities must be conducted such that:

(i) The received level of SURTASS LFA sonar transmissions will not exceed 180 dB within 22 km (12 nmi) from any emergent land, including offshore islands;

(ii) The received level of SURTASS LFA sonar transmissions will not exceed 180 dB re: 1 μPa (rms) at a distance less than 1 km (0.5 nmi) seaward of the outer perimeter of any Offshore Biologically Important Area (OBIA) designated in the Study Area for SURTASS LFA sonar in § 218.234(f)(2), or subsequently identified through the Adaptive Management process specified in § 218.241, during the period specified. The boundaries and periods of such OBIAs will be kept on file in NMFS' Office of Protected Resources and on its website at https://www.fisheries.noaa.gov/national/marine-mammal-protection/incidental-take-authorizations-military-readiness-activities.

(iii) No more than 25 percent of the authorized amount (transmission hours) of SURTASS LFA sonar for training and testing will be conducted within 10 nautical miles (18.5 km) of any single OBIA during any year (no more than 124 hours in years 1 to 4 and 148 hours in years 5 to 7) unless the following conditions are met: Should national security present a requirement to conduct more than 25 percent of authorized hours of SURTASS LFA sonar within 10 nautical miles (18.5km) of any single OBIA during any year, naval units will obtain permission from the appropriate designated Command authority prior to commencement of the activity. The Navy will provide NMFS with notification as soon as is practicable and include the information (e.g., sonar hours) in its annual activity reports submitted to NMFS.

(iv) No activities with the SURTASS LFA sonar system will occur within territorial seas of foreign nations, which are areas from 0 up to 12 nmi from shore, depending on the distance that individual nations claim; and

(v) No activities with the SURTASS LFA sonar system will occur within Hawaii state waters (out to 3 nmi) or in the waters of Penguin Bank and ensonification of Hawaii state waters will not be at levels above 145 dB.

(2) Offshore Biologically Important Areas (OBIAs) for marine mammals (with specified periods) for SURTASS LFA sonar training and testing activities include the following (See Table 7).

(g) Minimization of additional harm to live-stranded (or milling) mammals. The Navy must consult the Notification and Reporting Plan, which sets out the requirements for when live stranded marine mammals are reported in the Study Area. The Stranding and Notification Plan is available at: https://www.fisheries.noaa.gov/action/incidental-take-authorization-us-navy-operations-surveillance-towed-array-sensor-system-0

Requirements for Monitoring (§218.235)

(a) The Navy must:
  (1) Conduct visual monitoring from the ship's bridge during all daylight hours (30 minutes before sunrise until 30 minutes after sunset). During training and testing activities that employ SURTASS LFA sonar in the active mode, the SURTASS vessels must have lookouts to maintain a topside watch with standard binoculars (7x) and with the naked eye.
  (2) Use the passive SURTASS sonar component to detect vocalizing marine mammals; and
  (3) Use the HF/M3 sonar to locate and track marine mammals in relation to the SURTASS LFA sonar vessel and the LFA mitigation zone, subject to the ramp-up requirements in § 216.234(e) of this chapter.

(b) Monitoring under paragraph (a) of this section must:
  (1) Commence at least 30 minutes before the first SURTASS LFA sonar training and testing transmission;
  (2) Continue between transmission pings; and
  (3) Continue either for at least 15 minutes after completion of the SURTASS LFA sonar training and testing transmission, or, if marine mammals are exhibiting unusual changes in behavioral patterns, until behavior patterns return to normal or conditions prevent continued observations.

(c) The Navy must designate qualified on-site individuals to conduct the mitigation, monitoring and reporting activities specified in these regulations and LOA issued under §§ 216.106 of this chapter and 218.237.

(d) The Navy must continue to assess data from the Marine Mammal Monitoring Program and work toward making some portion of that data, after appropriate security reviews, available to scientists with appropriate clearances. Any portions of the analyses conducted by these scientists based on these data that are determined to be unclassified after appropriate security reviews will be made publically available.

(e) The Navy must collect ambient noise data and will explore the feasibility of declassifying and archiving the ambient noise data for incorporation into appropriate ocean noise budget efforts.

(f) The Navy must conduct all monitoring required under LOAs.

Requirements for Reporting (§218.236)

(a) The Navy must submit classified and unclassified annual mission reports to the Director, Office of Protected Resources, NMFS, no later than 60 days after the end of each year covered by the LOA beginning on the date of effectiveness of a LOA. Each annual mission report will include a summary of all active-mode missions completed during that year. At a minimum, each classified mission report must contain the following information:
    (1) Dates, times, and location of each vessel during each mission;
    (2) Information on sonar transmissions during each mission;
    (3) Results of the marine mammal monitoring program specified in the LOA; and
    (4) Estimates of the percentages of marine mammal species and stocks affected (both for the year and cumulatively for each successive year) covered by the LOA.

(b) The seventh annual report must be prepared as a final comprehensive report, which will include information for the final year as well as the prior six years of activities under the rule. This final comprehensive report must also contain an unclassified analysis of new passive sonar technologies and an assessment of whether such a system is feasible as an alternative to SURTASS LFA sonar, and be submitted to the Director, Office of Protected Resources, NMFS as described in this paragraph (a).

(c) The Navy will continue to assess the data collected by its undersea arrays and work toward making some portion of that data, after appropriate security reviews, available to scientists with appropriate clearances. Any portions of the analyses conducted by these scientists based on these data that are determined to be unclassified after appropriate security reviews will be made publically available.

(d) The Navy must consult the Notification and Reporting Plan, which sets out notification, reporting, and other requirements for when dead, injured, or live stranded marine mammals are reported in the Study Area. The Stranding and Notification Plan is available at: https://www.fisheries.noaa.gov/action/incidental-take-authorization-us-navy-operations-surveillance-towed-array-sensor-system-0

Letter of Authorization (§218.237)

(a) To incidentally take marine mammals pursuant to these regulations, Navy must apply for and obtain a LOA.

(b) An LOA, unless suspended or revoked, may be effective for a period of time not to exceed the expiration date of these regulations.

(c) If an LOA expires prior to the expiration date of these regulations, Navy may apply for and obtain a renewal of the LOA.

(d) In the event of projected changes to the activity or to mitigation and monitoring measures required by an LOA (excluding changes made pursuant to the adaptive management provision of § 218.239), the Navy must apply for and obtain a modification of the LOA as described in § 218.238.

(e) The LOA shall set forth:

(1) Permissible methods of incidental taking;
(2) Means of effecting the least practicable adverse impact on the species, its habitat, and on the availability of the species for subsistence uses (i.e., mitigation); and
(3) Requirements for monitoring and reporting.

(f) Issuance of the LOA will be based on a determination that the level of taking will be consistent with the findings made for the total taking allowable under these regulations.

(g) Notice of issuance or denial of an LOA will be published in the Federal Register within thirty days of a determination.

Renewal of Letters of Authorization (§218.238)

(a) An LOA issued under § 216.106 of this chapter and § 218.237 for the activity identified in § 218.230 may be renewed or modified upon request by the applicant, provided that:
(1) The planned specified activity and mitigation, monitoring, and reporting measures, as well as the anticipated impacts, are the same as those described and analyzed for the regulations in this subpart (excluding changes made pursuant to the adaptive management provision in paragraph (c)(1) of this section); and
(2) NMFS determines that the mitigation, monitoring, and reporting measures required by the previous LOA(s) were implemented.

(b) For LOA modification or renewal requests by the applicant that include changes to the activity or to the mitigation, monitoring, or reporting measures (excluding changes made pursuant to the adaptive management provision in paragraph (c)(1) of this section) that do not change the findings made for the regulations or result in no more than a minor change in the total estimated number of takes (or distribution by species or stock or years), NMFS may publish a notice of planned LOA in the Federal Register, including the associated analysis of the change, and solicit public comment before issuing the LOA.

(c) An LOA issued under § 216.106 of this chapter and § 218.237 may be modified by NMFS under the following circumstances:
(1) *Adaptive management*. After consulting with the Navy regarding the practicability of the modifications, NMFS may modify (including adding or removing measures) the existing mitigation, monitoring, or reporting measures if doing so creates a reasonable likelihood of more effectively accomplishing the goals of the mitigation and monitoring.
(i) Possible sources of data that could contribute to the decision to modify the mitigation, monitoring, or reporting measures in an LOA include:
A. Results from the Navy's monitoring from the previous year(s);
B. Results from other marine mammal and/or sound research or studies; or
C. Any information that reveals marine mammals may have been taken in a manner, extent, or number not authorized by the regulations in this subpart or subsequent LOAs.

(ii) If, through adaptive management, the modifications to the mitigation, monitoring, or reporting measures are substantial, NMFS will publish a notice of planned LOA in the Federal Register and solicit public comment.

(2) *Emergencies*. If NMFS determines that an emergency exists that poses a significant risk to the well-being of the species or stocks of marine mammals specified in LOAs issued pursuant to § 216.106 of this chapter and § 218.237, an LOA may be modified without prior notice or opportunity for public comment. Notice would be published in the Federal Register within thirty days of the action.

3.5.1.2 *MMPA Take Estimates for the Proposed Rule*

As described previously in the Navy's proposed action (Section 3.1), under the proposed MMPA regulation, the Navy may operate in the western and central North Pacific and eastern Indian oceans for testing and training. This does not include use of SURTASS LFA sonar in armed conflict, direct combat support operations, or use of SURTASS LFA sonar in support of military operations directed by the National Command Authorities. It is not feasible for the Navy or NMFS to estimate take of all marine mammal species and stocks for all potential areas for all seasons within the action area. For this reason and for MMPA regulations, the Navy selected 15 model areas representative of the different geographic locations where the Navy may operate SURTASS LFA sonar over the next seven years. In each of these model areas, the Navy estimated take of marine mammal species (refer to Section 2.1.1 for a more detailed description of the process used to estimate take of marine mammals for the proposed rule) for a single 24-hour transmission in that location. These take estimates are provided below and in the proposed MMPA rule. NMFS' Permits and Conservation Division believes these estimates provide a reasonable upper estimate for SURTASS LFA sonar training and testing activities, and under the framework established by the proposed MMPA rule, specific take numbers for all seven years of activity are requested in the application for issuance of a single LOA for SURTASS LFA sonar training and testing activities from 2019 to 2026. Below we provide the MMPA take estimates for ESA-listed marine mammals that were modeled by the Navy (See Table 8, Table 9, and Table 10).

Table 8. Maximum Total Annual Marine Mammal Protection Act (MMPA) Level B Harassment Estimated for Years 1 to 4 by SURTASS LFA Sonar (Species, Stocks, and DPSs Listed Alphabetically).

Marine Mammal Species	*Stock or DPS*[9]	*Maximum Annual MMPA Level B Harassment: Years 1 to 4*[10]					
		Behavior	*Behavior (Percent Stock)*	*TTS*	*TTS (Percent Stock)*	*Total Level B*	*Total Level B (Percent Stock)*
Blue whale	CNP	3.12	2.39%	0	0.00%	3	2.39%
	NIND	0.43	0.00%	0	0.00%	0	0.00%
	WNP	6.58	0.07%	83	0.83%	90	0.90%
	SIND	0.81	0.07%	0	0.00%	1	0.07%
Fin whale	ECS	1.88	0.37%	7	1.42%	9	1.80%
	Hawaii	3.49	2.30%	0	0.00%	3	2.30%
	IND	0.14	0.00%	0	0.00%	0	0.00%
	SIND	13.17	0.04%	9	0.02%	22	0.05%
	WNP	259.28	2.85%	2,299	24.70%	2,558	27.55%
Humpback whale	WNP stock and DPS	315.07	23.82%	2,788	210.03%	3,103	233.84%
North Pacific right whale	WNP	3.65	0.33%	85	9.24%	89	9.57%
Sei whale	Hawaii	9.46	2.39%	9	2.39%	19	4.78%
	SIND	0.16	0.00%	0	0.00%	0	0.00%
	NP	114.31	1.63%	3,058	43.73%	3,172	45.37%
	NIND	3.93	0.04%	0	0.00%	4	0.04%
Western North Pacific gray whale	WNP stock and Western DPS	0.45	0.15%	0	0.00%	0	0.00%

[9] CNP=Central North Pacific; NP=North Pacific; WNP=Western North Pacific; ECS=East China Sea; NIND=Northern Indian; SIND=Southern Indian; IND=Indian; DPS=distinct population segment

[10] As stated in Section 2.1.1, individuals are only considered for one acoustic exposure during a 24-hr period. As a result, a single animal can be represented more than once in the calculated number of exposures from TTS and behavioral harassment during years 1 through 4 of SURTASS LFA sonar training and testing activities.

Marine Mammal Species	*Stock or DPS*[9]	*Maximum Annual MMPA Level B Harassment: Years 1 to 4*[10]					
		Behavior	*Behavior (Percent Stock)*	*TTS*	*TTS (Percent Stock)*	*Total Level B*	*Total Level B (Percent Stock)*
False killer whale	Main Hawaiian Islands Insular stock and DPS	0.69	0.41%	0	0.00%	1	0.41%
Sperm whale	Hawaii	105.88	2.34%	0	0.00%	106	2.34%
	NIND	33.32	0.14%	0	0.00%	33	0.14%
Sperm whale (Continued)	NP	1,429.07	1.28%	0	0.00%	1,429	1.28%
	SIND	15.70	0.07%	0	0.00%	16	0.07%
Hawaiian monk seal	Hawaii	9.71	0.69%	0	0.00%	10	0.69%
Spotted seal	Southern stock and DPS	0.43	0.03%	0	0.00%	0	0.00%
Western Steller sea lion	Western/Asian stock, Western DPS	2.17	0.00%	0	0.00%	2	0.00%

Table 9. Maximum Total Annual MMPA Level B Harassment Estimated for Years 5 through 7 by SURTASS LFA Sonar (Species, Stocks, and DPSs Listed Alphabetically).

Marine Mammal Species	*Stock or DPS*[11]	*Maximum Annual MMPA Level B Harassment: Years 5+*[12]					
		Behavior	*Behavior (Percent Stock)*	*TTS*	*TTS (Percent Stock)*	*Total Level B*	*Total Level B (Percent Stock)*
Blue whale	CNP	3.73	2.85%	0	0.00%	4	2.85%
	NIND	0.59	0.00%	0	0.00%	1	0.00%
	WNP	8.44	0.00%	114	1.14%	123	1.14%
	SIND	0.81	0.07%	0	0.00%	1	0.07%

[11] CNP=Central North Pacific; NP=North Pacific; WNP=Western North Pacific; ECS=East China Sea; NIND=Northern Indian; SIND=Southern Indian; IND=Indian; DPS=distinct population segment

[12] As stated in Section 2.1.1, individuals are only considered for one acoustic exposure during a 24-hr period. As a result, a single animal can be represented more than once in the calculated number of exposures from TTS and behavioral harassment during years 5 through 7 of SURTASS LFA sonar training and testing activities.

Marine Mammal Species	***Stock or DPS***[11]	***Maximum Annual MMPA Level B Harassment: Years 5+***[12]					
		Behavior	***Behavior (Percent Stock)***	***TTS***	***TTS (Percent Stock)***	***Total Level B***	***Total Level B (Percent Stock)***
Fin whale	ECS	2.59	0.51%	10	1.96%	12	2.47%
	Hawaii	4.17	2.74%	0	0.00%	4	2.74%
	IND	0.20	0.00%	0	0.00%	0	0.00%
	SIND	18.11	0.05%	12	0.02%	30	0.07%
	WNP	347.52	3.81%	3,107	33.42%	3,455	37.23%
Humpback whale	WNP stock and DPS	381.92	28.87%	3,884	292.62%	4,266	321.49%
North Pacific right whale	WNP	4.77	0.44%	117	12.71%	122	13.15%
Sei whale	Hawaii	11.29	2.85%	11	2.85%	22	5.70%
	SIND	0.22	0.00%	0	0.00%	0	0.00%
	NP	156.58	2.23%	4,204	60.13%	4,361	62.37%
	NIND	5.40	0.05%	0	0.00%	5	0.05%
Western North Pacific gray whale	WNP stock and Western DPS	0.59	0.20%	0	0.00%	1	0.20%
False killer whale	Main Hawaiian Islands Insular stock and DPS	0.82	0.49%	0	0.00%	1	0.49%
Sperm whale	Hawaii	126.38	2.80%	0	0.00%	126	2.80%
	NIND	45.81	0.20%	0	0.00%	46	0.20%
	NP	1,855.21	1.68%	0	0.00%	1,855	1.68%
	SIND	21.58	0.10%	0	0.00%	22	0.10%
Hawaiian monk seal	Hawaii	12.75	0.91%	0	0.00%	13	0.91%
Spotted seal	Southern stock and DPS	0.59	0.04%	0	0.00%	1	0.04%
Western Steller sea lion	Western/Asian stock, Western DPS	2.98	0.00%	0	0.00%	3	0.00%

Table 10. Overall Estimated MMPA Level B Harassment for Seven-Year SURTASS LFA Sonar Training and Testing Activities

Species	Stock or DPS[13]	Total Overall Level B Harassment for 7-year Period[14]
Blue whale	CNP	24
	NIND	3
	WNP	729
	SIND	7
Fin whale	ECS	72
	Hawaii	24
	IND	0
	SIND	178
	WNP	20,597
Humpback whale	WNP stock and DPS	25,210
North Pacific right whale	WNP	722
Sei whale	Hawaii	142
	SIND	0
	NP	25,771
	NIND	31
Western North Pacific gray whale	WNP stock and Western DPS	3
False killer whale	Main Hawaiian Islands Insular stock and DPS	7
Sperm whale	Hawaii	802
	NIND	270

[13] CNP=Central North Pacific; NP=North Pacific; WNP=Western North Pacific; ECS=East China Sea; NIND=Northern Indian; SIND=Southern Indian; IND=Indian; DPS=distinct population segment

[14] As stated in Section 2.1.1, individuals are only considered for one acoustic exposure during a 24-hr period. As a result, a single animal can be represented more than once in the calculated number of exposures from TTS and behavioral harassment during the seven years of SURTASS LFA sonar training and testing activities.

Species	Stock or DPS[13]	Total Overall Level B Harassment for 7-year Period[14]
	NP	11,281
	SIND	130
Hawaiian monk seal	Hawaii	79
Spotted seal	Southern stock and DPS	3
Steller sea lion	Western/Asian stock, Western DPS	17

3.5.2 Issuance of a Letter of Authorization

LOAs, which may be issued only to U.S. citizens, are required to conduct activities pursuant to MMPA regulations. Letters of authorization must include general mitigation and monitoring as described in the Federal regulations, but can also further restrict the authorized activities based on the specific areas, times, or activities to be done. Letters of authorization issued by NMFS must include the following:

- The permissible methods of taking;
- The means of effecting the least practicable adverse impact on the species or stock and its habitat, paying particular attention to rookeries, mating grounds, and areas of similar significance, and on the availability of species or stocks for subsistence uses,
- Monitoring and reporting requirements.

Requests for letters of authorization are submitted to the Director, Office of Protected Resources. Issuance of a LOA is based on a determination that the level of taking is consistent with the findings made for the total taking allowable under the specific regulations. Notice of issuance of letters of authorization are published in the *Federal Register* within 30 days of issuance. Letters of authorization are withdrawn or suspended, either on an individual or class basis, as appropriate, if, after notice and opportunity for public comment, NMFS' Permits and Conservation Division determines that: 1) the regulations prescribed are not being substantially complied with; or 2) the taking allowed is having, or may have, more than a negligible impact on the species or stock or, when relevant, an unmitigable adverse impact on the availability of the species or stock for subsistence uses. A violation of any of the terms and conditions of a LOA or of the specific regulations shall subject the holder of the LOA, and/or any individual who is operating under the authority of the holder's LOA, to penalties provided in the MMPA.

In this case, the Navy has petitioned NMFS for incidental take regulations under the MMPA to cover seven years of SURTASS LFA sonar training and testing activities (section 3.5.1), and further requested a single seven-year LOA for SURTASS LFA sonar training and testing activities.

3.6 Action Area

Action area means all areas affected directly, or indirectly, by the Federal action, and not just the immediate area involved in the action (50 C.F.R. §402.02). The geographic scope of the previous MMPA documents for SURTASS LFA sonar routine training, testing, and military operations was the non-polar areas of the Atlantic, Pacific, and Indian oceans and the Mediterranean Sea. The action area for this consultation includes the western and central North Pacific and eastern Indian oceans (See Figure 2), not including polar waters or the Sea of Okhotsk. The Navy has reduced the geographic scope of its proposed use of SURTASS LFA sonar systems to reflect more clearly the marine areas where the Navy anticipates conducting SURTASS LFA sonar activities for the foreseeable future. This refinement in the geographic scope would allow the

Navy's environmental analyses to be more focused and efficient, as they would concentrate only on areas where the Navy's SURTASS LFA sonar activities may be conducted.

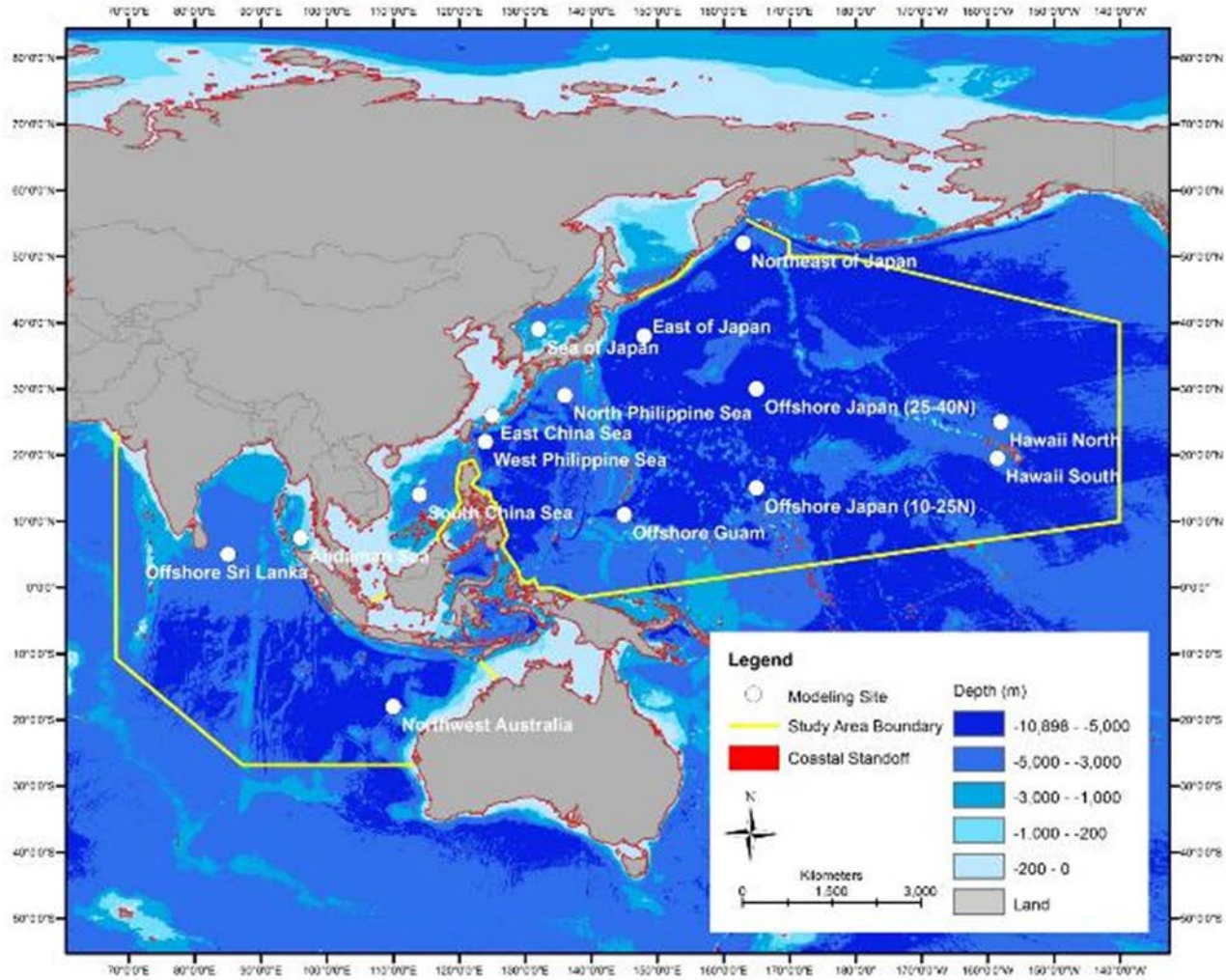

Figure 2. Location of the Action Area for SURTASS LFA Sonar in the Western and Central North Pacific and Eastern Indian Oceans.

As shown above, the Navy selected fifteen representative model areas, with nominal modeling sites in each region to provide more geographic context for SURTASS LFA sonar training and testing activities.

Within this geographic scope, NMFS and the Navy developed mitigation measures to reduce the potential for adverse impacts, which include two geographic restrictions, the coastal standoff range and OBIAs. As such, during SURTASS LFA sonar training and testing activities, RLs would be below 180 dB re 1 µPa (rms) within 12 nmi (22 km) of any emergent land and within the boundary of a designated OBIA during its respective effective period when significant biological activity occurs.

3.7 Interrelated and Interdependent Actions

Interrelated actions are those that are part of a larger action and depend on that action for their justification. *Interdependent* actions are those that do not have independent utility apart from the action under consideration. NMFS determined that there are no interrelated or interdependent actions outside the scope of Navy's SURTASS LFA sonar routine training and testing activities and NMFS's proposed promulgation of MMPA regulations and subsequent issuance of letters of authorization pursuant to the MMPA regulation as described in this opinion.

4 POTENTIAL STRESSORS

Stressors are any physical, chemical, or biological entity that may induce an adverse response either in an ESA-listed species or their designated critical habitat. NMFS' Permits and Conservation Division's rulemaking and LOA issuance for the Navy's proposed SURTASS LFA sonar training and testing activities would authorize activities that may expose ESA-listed species to a variety of stressors. These stressors include acoustic disturbance, vessel strike, vessel discharge, and entanglement. Each of these stressors are discussed below.

4.1 Acoustic Disturbance

The proposed action would produce a variety of different sounds including those associated with T-AGOS vessel operations, LFA sonar, and HF/M3 sonar. Each of these sources produce sounds that may cause acoustic disturbance to ESA-listed species.

4.1.1 Vessel Noise

Navy vessel traffic could occur anywhere within the action area. During training and testing the operational speed of all vessels during SURTASS LFA sonar training and testing activities will be approximately 5.6 kph (3 kt), and each vessel's cruising speed outside of SURTASS LFA sonar training and testing activities would be a maximum of approximately 18.5 to 24.1 kph (10 to 13 kt). While the discussion below focuses on the potential effects of vessel noise on marine mammals, it should be noted that it is often difficult to differentiate between the influence of sound exposure from vessels and the physical presence of vessels (e.g., Ng and Leung 2003).

Sounds emitted by large vessels (such as SURTASS LFA vessels) can be characterized as low-frequency, continuous, or tonal, and sound pressure levels at a source will vary according to speed, burden, capacity, and length (Richardson et al. 1995b; Kipple and Gabriele 2007; Mckenna et al. 2012). Vessels ranging from 135 to 337 m (442.9 to 1,105.6 ft) generate peak source sound levels from 169 to 200 dB between 8 to 430 Hz. SLs for 593 container ship transits were estimated from long-term acoustic recording received levels in the Santa Barbara shipping channel, and a simple transmission loss model using Automatic Identification System data for source-receiver range (McKenna et al. 2013). Ship noise levels could vary 5 to 10 dB depending on transit conditions. Given the sound propagation of low frequency sounds, a large vessel in this sound range can be heard 139 to 463 km (75 to 250 nmi) away (Polefka 2004). Hatch et al. (2008) measured commercial ship underwater noise levels and reported average SL estimates (71

to 141 Hz) for individual vessels ranged from 158±2 dB (research vessel) to 186±2 dB (oil tanker).

We recognize that SURTASS LFA sonar vessels almost certainly incorporate quieting technologies that reduce their acoustic signature (relative to the acoustic signature of similarly size vessels) in order to reduce their vulnerability to detection by enemy vessels (Southall 2005). Additionally, the slow ship speeds of SURTASS LFA sonar vessels result in very little engine or propeller cavitation noise being generated into the surrounding marine environment (Navy 2015). Nevertheless, we do not assume that any quieting technology or low travel speeds would be sufficient to prevent marine animals from detecting sounds produced by approaching Navy vessels and perceive those sounds as predatory stimuli. We also consider evidence that factors other than received sound level, including the activity state of animals exposed to different sounds, the nature and novelty of a sound, and spatial relations between sound source and receiving animals (i.e., the exposure context) strongly affect the probability of a behavioral response (Ellison et al. 2012a).

4.1.1.1 *Effects of Vessel Noise on ESA listed Marine Mammals*

Numerous studies of interactions between surface vessels and marine mammals have demonstrated that free-ranging marine mammals engage in avoidance behavior when surface vessels move toward them. It is not clear whether these responses are caused by the physical presence of a surface vessel, the underwater noise generated by the vessel, or an interaction between the two (Bryant et al. 1984; Bauer 1986; Watkins 1986a; Corkeron 1995; Wursig et al. 1998; Bejder et al. 1999; Au and Green 2000b; Felix 2001; Nowacek et al. 2001; Erbe 2002b; Magalhaes et al. 2002; Williams et al. 2002c; Lusseau 2003; Richter et al. 2003c; Goodwin and Cotton 2004; Scheidat et al. 2004; Amaral and Carlson 2005; Simmonds 2005; Bain et al. 2006; Lemon et al. 2006; Lusseau 2006; Bejder and Lusseau. 2008; Bejder et al. 2009). However, several authors suggest that the noise generated during motion is probably an important factor (Evans et al. 1992; Blane and Jaakson 1994; Evans et al. 1994). These studies suggest that the behavioral responses of marine mammals to surface vessels are similar to their behavioral response to predators.

Baleen whales demonstrate a variety of responses to vessel traffic and noise, from not responding at all to both horizontal (swimming away) and vertical (increased diving) avoidance (Watkins 1981a; Baker et al. 1983; Gende et al. 2011). Other common responses include changes in vocalizations, surface time, swimming speed, swimming angle or direction, respiration rates, dive times, feeding behavior, and social interactions (Au and Green 2000b; Williams et al. 2002b; Richter et al. 2003b).

Based on the suite of studies of cetacean behavior to vessel approaches, the set of variables that help determine whether marine mammals are likely to be disturbed by surface vessels include:

- *The number of vessels*. The behavioral repertoire marine mammals have used to avoid interactions with surface vessels appears to depend on the number of vessels in their

perceptual field (the area within which animals detect acoustic, visual, or other cues) and the animal's assessment of the risks associated with those vessels (the primary index of risk is probably vessel proximity relative to the animal's flight initiation distance (Sims et al. 2012). Below a threshold number of vessels (which varies from one species to another, although groups of marine mammals probably share sets of patterns), studies have shown that whales will attempt to avoid an interaction using horizontal avoidance behavior. Above that threshold, studies have shown that marine mammals will tend to avoid interactions using vertical avoidance behavior, although some marine mammals will combine horizontal avoidance behavior with vertical avoidance behavior (Bryant et al. 1984; Kruse 1991; Nowacek et al. 2001; Williams et al. 2002c; Lusseau 2003; Stensland and Berggren 2007; Williams and Ashe 2007);

- *The distance between vessel and marine mammals* when the animal perceives that an approach has started and during the course of the interaction (Au and Perryman 1982; Hewitt 1985; Kruse 1991; Williams et al. 2002c; Lusseau 2003; Tseng et al. 2011; Lundquist et al. 2012);
- *The vessel's speed and vector* (Williams et al. 2002c);
- *The predictability of the vessel's path*. That is, cetaceans are more likely to respond to approaching vessels when vessels stay on a single or predictable path (Acevedo 1991; Angradi et al. 1993; Browning and Harland. 1999; Williams et al. 2002a; Lusseau 2003; Lusseau 2006);
- *The noise associated with the vessel* (particularly engine noise) and the rate at which the engine noise increases (which the animal may treat as evidence of the vessel's speed) (Williams et al. 2002c; Lusseau 2003; Lusseau 2006; Polagye et al. 2011);
- *The type of vessel* (displacement versus planing), which marine mammals may be interpret as evidence of a vessel's maneuverability (Goodwin and Cotton 2004);
- *The behavioral state of the marine mammals* (Wursig et al. 1998; Williams et al. 2002c; Lusseau 2003; Lusseau 2006). For example, Würsig et al. (1998) concluded that whales were more likely to engage in avoidance responses when the whales were milling or resting than during other behavioral states (Wursig et al. 1998).

Most of the investigations reported that cetaceans tended to reduce their visibility at the water's surface and move horizontally away from the source of disturbance or adopt erratic swimming strategies (Corkeron 1995; Nowacek et al. 2001; Van Parijs and Corkeron 2001; Williams et al. 2002a; Williams et al. 2002c; Lusseau 2003; Lusseau 2004; Lundquist et al. 2012). In the process, their dive times increased, vocalizations and jumping were reduced (with the exception of beaked whales), individuals in groups move closer together, swimming speeds increased, and their direction of travel took them away from the source of disturbance (Edds and Macfarlane 1987; Baker and Herman 1989; Kruse 1991; Evans et al. 1992). Some individuals also dove and

remained motionless, waiting until the vessel moved past their location. Most animals finding themselves in confined spaces, such as shallow bays, during vessel approaches tended to move towards more open, deeper waters (Kruse 1991). We assume that this movement would give them greater opportunities to avoid or evade vessels as conditions warranted.

Mysticetes have been shown to both increase and decrease calling behavior in the presence of vessel noise. Based on passive acoustic recordings and in the presence of sounds from passing vessels, Melcon et al. (2012) reported that blue whales had an increased likelihood of producing certain types of calls. An increase in feeding call rates and repetition by humpback whales in Alaskan waters is associated with vessel noise (Doyle et al. 2008), while decreases in singing activity have been noted near Brazil due to boat traffic (Sousa-Lima and Clark 2008). Frequency parameters of fin whale calls also decreased in the presence of increasing background noise due to shipping traffic (Castellote et al. 2012b). Bowhead whales avoided the area around icebreaker ship noise and increased their time at the surface and number of blows (Richardson et al. 1995d). Right whales increase the amplitude or frequency of their vocalizations or called at a lower rate in the presence of increased vessel noise (Parks et al. 2007a; Parks 2011), and these vocalization changes may persist over long periods if background noise levels remain elevated.

The long-term consequences of vessel noise on whales are not well understood. In a short-term study, minke whales on feeding grounds in Iceland responded to increased whale watching vessel traffic with a decrease in foraging, both during deep dives and at the surface (Christiansen et al. 2013). They also increased their avoidance of the boats while decreasing their respiration rates, likely leading to an increase in their metabolic rates. Christiansen and Lusseau (2015) followed up this study by modeling the cumulative impacts of whale watching boats on minke whales, but found that although the boats cause temporary feeding disruptions, there were not likely to be long-term consequences as a result. This suggests that short-term responses may not lead to long-term consequences, and that over time animals may habituate to the presence of vessel traffic. Using historical records, Watkins (1986b) showed that the reactions of four species of mysticetes to vessel traffic and whale watching activities in Cape Cod had changed over the 25-year period examined (1957 to 1982). Reactions of minke whales changed from initially more positive reactions, such as coming towards the boat or research equipment to investigate, to more uninterested reactions towards the end of the study. Fin whales, the most numerous species in the area, showed a trend from initially more negative reactions, such as swimming away from the boat with limited surfacing, to more uninterested (ignoring) reactions allowing boats to approach within 30 m. Right whales showed little change over the study period, with a roughly equal number of reactions judged to be negative and uninterested; no right whales were noted as having positive reactions to vessels. Humpback whales showed a trend from negative to positive reactions with vessels during the study period. The author concluded that the whales had habituated to the human activities over time (Watkins 1986b).

Overall, baleen whale responses to vessel noise and traffic are varied but are generally minor, and habituation or disinterest seems to be the predominant long-term response. If baleen whales

do avoid ships, they do so by altering their swim and dive patterns to move away from the vessel, but no strong reactions have been observed. In many cases, whales do not appear to change their behavior at all. This may result from habituation by the whales, but may also result from reduced received levels near the surface due to propagation, or due to acoustic shadowing of the propeller cavitation noise by the ship's hull.

Similar to mysticetes, odontocete responses to vessel noise are varied. Some species, in particular killer whales and porpoises, may be sensitized to vessels and respond at further distances and lower received levels than other delphinids. In contrast, many odontocete species also approach vessels to bowride, indicating either that these species are less sensitive to vessels, or that the behavioral drive to bowride supersedes any impact of the associated noise.

Marine mammals (specifically cetaceans) may also experience masking due to vessel noises. For example, right whales were observed to shift the frequency content of their calls upward while reducing the rate of calling in areas of increased anthropogenic noise (Parks et al. 2007a) as well as increasing the amplitude (intensity) of their calls (Parks et al. 2009a; Parks et al. 2011a). Right whales also had their communication space reduced by up to 84 percent in the presence of vessels (Clark et al. 2009a). Although humpback whales did not change the frequency or duration of their vocalizations in the presence of ship noise, their SLs were lower than expected, potentially indicating some signal masking (Dunlop 2016).

Vessel noise can potentially mask vocalizations and other biologically important sounds (e.g., sounds of prey or predators) that marine mammals may rely on. Potential masking can vary depending on the ambient noise level within the environment, the received level and frequency of the vessel noise, and the received level and frequency of the sound of biological interest. In the open ocean, ambient noise levels are between about 60 and 80 dB re 1 µPa (rms) in the band between 10 Hz and 10 kHz due to a combination of natural (e.g., wind) and anthropogenic sources (Urick 1983), while inshore noise levels, especially around busy harbors and ports, can exceed 120 dB re 1 µPa (rms). When the noise level is above the sound of interest, and in a similar frequency band, masking could occur. This analysis assumes that any sound that is above ambient noise levels and within an animal's hearing range may potentially cause masking. However, the degree of masking increases with increasing noise levels; a noise that is just detectable over ambient levels is unlikely to cause any substantial masking.

Pinniped reactions to vessels are variable and reports include a wide spectrum of possibilities from avoidance and alert, to cases where animals in the water are attracted, and cases on land where there is lack of significant reaction suggesting habituation to or tolerance of vessels (Richardson et al. 1995e). Specific case reports in Richardson et al. (1995e) vary based on factors such as routine anthropogenic activity, distance from the vessel, engine type, wind direction, and ongoing subsistence hunting. As with reactions to sound reviewed by Southall et al. (2007b), pinniped responses to vessels are affected by the context of the situation and by the animal's experience.

Anderwald et al. (2013) investigated grey seal reactions to an increase in vessel traffic off Ireland's coast in association with construction activities, and their data suggests the number of vessels had an indeterminate effect on the seals' presence. Harbor seals haulout on tidewater glaciers in Alaska, and most haulouts occur during pupping season. Blundell & Pendleton (2015) found that the presence of any vessel reduces haulout time, but cruise ships and other large vessels in particular shorten haulout times. Another study of reactions of harbor seals hauled out on ice to cruise ship approaches in Disenchantment Bay, Alaska, revealed that animals are more likely to flush and enter the water when cruise ships approach within 500 m and four times more likely when the cruise ship approaches within 100 m (Jansen et al. 2010). Karpovich et al. (2015) also found that harbor seal heart rates increased when vessels were present during haulout periods, and increased further when vessels approached and animals re-entered the water. Harbor seals responded more to vessels passing by haulout sites in areas with less overall vessel activity, and the model best predicting their flushing behavior included the number of boats, type of boats, and distance to boats. More flushing occurred to non-motorized vessels (e.g. kayaks), likely because they tended to occur in groups rather than as single vessels, and tended to pass closer (25 – 184 m) to the haulout sites than motorized vessels (55 – 591 m) (Cates and Acevedo-Gutiérrez 2017). Jones et al. (2017) also modeled the spatial overlap of vessel traffic and grey and harbor seals in the United Kingdom, and found most overlap to occur within 50 km of the coast, and high overlap occurring within 5 of 13 grey seal Special Areas of Conservation and within 6 of 12 harbor seal Special Areas of Conservation. They also estimated received levels of shipping noise and found maximum daily M-weighted cSEL values from 170 – 189 dB, with the upper confidence intervals of those estimates sometimes exceeding TTS values. However, there was no evidence of reduced population size in an of these high overlap areas.

The ESA-listed marine mammals considered in this opinion will be exposed to noise from Navy vessels during training and testing activities in the action area. As documented above, vessel noise has the potential to disturb marine mammals and elicit an alerting, avoidance, or other behavioral reaction. These reactions are anticipated to be short-term, likely lasting the amount of time the vessel and the whale are in close proximity (e.g., Watkins 1981a; Richardson et al. 1995f; Magalhaes et al. 2002), and not consequential to the animals. Additionally, short-term masking could occur. Masking by passing vessels or other sound sources transiting the action area would be short term and intermittent, and therefore unlikely to result in any substantial costs or consequences to individual animals or populations. In addition, there are only four SURTASS LFA sonar vessels that will be used during the first four years of activity. Also, due to the minimal increase in transmission hours from years five through seven of the proposed activity (shown in Table 2), only a negligible increase in new vessels coming online is expected to occur. As a result, SURTASS LFA sonar vessels are not expected to significantly contribute to overall background levels of underwater noise in the marine environment.

In summary, ESA-listed marine mammals are either not likely to respond to SURTASS LFA sonar vessel noise or are not likely to measurably respond in ways that would significantly disrupt normal behavior patterns that include, but are not limited to, breeding, feeding or

sheltering. Therefore, the effects of vessel noise on ESA-listed marine mammals and their corresponding critical habitat (i.e., Hawaiian Monk Seal and Main Hawaiian Insular false killer whale critical habitat) are insignificant (i.e., so minor that the effect cannot be meaningfully evaluated). As a result, we conclude that vessel noise is not likely to adversely affect ESA-listed marine mammals or their corresponding designated critical habitat in the action area.

4.1.1.2 *Effects of Vessel Noise on ESA listed Sea Turtles*

ESA-listed turtles could be exposed to a range of vessel noises within their hearing abilities. The Navy vessels used during SURTASS LFA sonar training and testing activities will produce low-frequency, broadband underwater sound below 1 kHz which are in the frequency range for sea turtles. However, very little research exists on sea turtle responses to vessel noise disturbance. Currently, there is nothing in the available literature specifically aimed at studying and quantifying sea turtle response to vessel noise. However, a study examining vessel strike risk to green sea turtles suggests that sea turtles may habituate to vessel sound and may be more likely to respond to the sight of a vessel rather than the sound of a vessel, although both may play a role in prompting reactions (Hazel et al. 2007). Regardless of the specific stressor associated with vessels to which turtles are responding, they only appear to show responses (i.e., avoidance behavior) at approximately 10 m or closer (Hazel et al. 2007). Therefore, the noise from vessels is not likely to affect sea turtles from further distances, and disturbance may only occur if a sea turtle hears a vessel nearby or sees it as it approaches. These responses appear limited to non-injurious, minor changes in behavior based on the limited information available on sea turtle response to vessel noise.

For these reasons, vessel noise is expected to cause minimal disturbance to sea turtles. If a sea turtle detects a vessel and avoids it, or has a temporary stress response from the noise disturbance, these responses are expected to be temporary and only endure while the vessel transits through the area where the sea turtle encountered it. Sea turtle responses to the vessel noise disturbance are considered insignificant, and a sea turtle would be expected to return to normal behaviors and baseline stress levels shortly after the vessel passes. In summary, we find that the likely effects from exposure to vessel noise are insignificant (i.e., so minor that the effect cannot be meaningfully evaluated) for all ESA-listed sea turtles in this consultation. Therefore, we conclude that vessel noise is not likely to adversely affect ESA-listed sea turtles in the action area.

4.1.1.3 *Effects of Vessel Noise on ESA listed Fishes*

For fishes, information regarding the effects of vessel noise on fish hearing and behaviors is limited. Although some TTS has been observed in fishes exposed to elevated background noise and other white noise, a continuous sound source similar to noise produced from vessels. Smith et al. (2004b) and Smith et al. (2006) exposed goldfish (a fish with hearing sensitivities unlike any of the ESA-listed species considered in this opinion) to noise with sound pressure level of 170 dB re 1 μPa and found a clear relationship between the amount of TTS and duration of exposure, until maximum hearing loss occurred at about 24 hours of exposure. A short duration

(e.g., 10-minute) exposure resulted in 5 dB of TTS, whereas a three-week exposure resulted in a 28 dB TTS that took over two weeks to return to pre-exposure baseline levels (Smith et al. 2004b). Recovery times were not measured by researchers for shorter exposure durations, so recovery time for lower levels of TTS was not documented.

Vessel noise may also affect fish behavior by causing them to startle, swim away from an occupied area, change swimming direction and speed, or alter schooling behavior (Engas et al. 1995; Engas et al. 1998; Mitson and Knudsen 2003). Physiological responses have also been documented for fish exposed to increased boat noise. Nichols et al. (2015) demonstrated physiological effects of increased noise (playback of boat noise) on coastal giant kelpfish. The fish exhibited acute stress responses when exposed to intermittent noise, but not to continuous noise. These results indicate variability in the acoustic environment may be more important than the period of noise exposure for inducing stress in fishes. However, other studies have also shown exposure to continuous or chronic vessel noise may elicit stress responses indicated by increased cortisol levels (Scholik and Yan 2001; Wysocki et al. 2006). These experiments demonstrate physiological and behavioral responses to various boat noises that could affect species' fitness and survival but may also be influenced by the context and duration of exposure. It is important to note that most of these exposures were continuous, not intermittent, and the fish were unable to avoid the sound source for the duration of the experiment because this was a controlled study. In contrast, wild fish are not hindered from movement away from an irritating sound source, if detected, so are less likely to subjected to accumulation periods that lead to the onset of hearing damage as indicated in these studies. In other cases, fish may eventually become habituated to the changes in their soundscape and adjust to the ambient and background noises.

All fish species can detect vessel noise due to its low-frequency content and their hearing capabilities. Navy vessels produce moderate to low-level passive sound sources. Therefore, ESA-listed fishes could be exposed to a range of vessel noises, depending on the source and context of the exposure. Because of the characteristics of vessel noise, sound produced from Navy vessels is unlikely to result in direct injury, hearing impairment, or other trauma to fishes. Moreover, in the near field, fish are able to detect water motion as well as visually locate an oncoming vessel. In these cases, most fishes located in close proximity that detect the vessel either visually, via sound and motion in the water would be capable of avoiding the vessel or move away from the area affected by vessel sound. Thus, fish are more likely to react to vessel noise at close range than to vessel noise emanating from a greater distance away. These reactions may include physiological stress responses, or avoidance behaviors. However, impacts from Navy vessel noise would be intermittent, temporary and localized, and such responses would not be expected to compromise the general health or condition of individual fish from continuous exposures. Instead, the only impacts expected from exposure to Navy vessel noise for fishes may include temporary auditory masking, physiological stress, or minor changes in behavior.

Therefore, similar to marine mammals and sea turtles, exposure to vessel noise for fishes could result in short-term behavioral or physiological responses (e.g., avoidance, stress). Vessel noise

would only result in brief periods of exposure for fishes and would not be expected to accumulate to the levels that would lead to any injury, hearing impairment or long-term masking of biologically relevant cues. For these reasons, exposure to vessel noise is not expected to significantly disrupt normal behavior patterns of fishes in the action area. Therefore, the effects of vessel noise on ESA-listed fishes is considered insignificant (i.e., so minor that the effect cannot be meaningfully evaluated). Therefore, we conclude that vessel noise is not likely to adversely affect ESA-listed fishes in the action area.

4.1.2 LFA Sonar

The LFA system consists of up to 18 low-frequency acoustic-transmitting projectors that are suspended from a cable beneath the ship. The SL of an individual projector in the LFA sonar array is about 215 dB re: 1 µPa (rms) at 1 m, and the sound field of the array can never have a sound pressure level higher than that of an individual projector. The typical LFA sonar signal is not a constant tone, but is a transmission of various signal types that vary in frequency and duration (including continuous wave and frequency-modulated signals). The Navy refers to a complete sequence of sound transmissions as a “ping” which can range from between six and 100 seconds, with no more than ten seconds at any single frequency. The time between pings will typically range from six to 15 minutes. The Navy can control the average duty cycle (the ratio of sound “on” time to total time) for the system but the duty cycle cannot exceed 20 percent. Based on operations since 2003, the duty cycle has averaged about 7.5 percent.

The LFA sonar mitigation zone covers a volume ensonified to a received level at or above 180 dB re: 1 µPa (rms) by the SURTASS LFA sonar transmit array. Based on spherical spreading(20logR), this zone will vary between the nominal ranges of 0.75 to one km (0.4 to 0.5 nmi) from the source array ranging over a depth of approximately 87 to 157 m (285 to 515 ft). The center of the array is at an approximate depth of 122 m (400 ft).

We assume that the propagation of signals transmitted from LFA sonar systems would be affected by surface ducts, sound channels, convergence zones, and bottom interactions. For a more complete discussion of sound propagation in marine environments, readers should refer to Richardson et al. (1995e), and Appendix B of the Navy EIS on SURTASS LFA sonar (Navy 2001b).

4.1.3 HF/M3 sonar

As a mitigation measure to reduce the exposure of marine animals and sea turtles to SURTASS LFA sonar, the Navy will operate the HF/M3 sonar continuously during the course of active sonar transmissions. The HF/M3 sonar is a Navy-developed, enhanced high-frequency commercial sonar designed to detect, locate, and track marine mammals and, to some extent, sea turtles and large fish (e.g., sharks, sturgeon) that may pass close enough to the SURTASS LFA sonar’s transmitter array to enter the LFA sonar mitigation and buffer zones. Analysis and testing of the HF/M3 sonar operating capabilities indicate that the system substantially increases the probability of detecting marine mammals within the LFA sonar mitigation and buffer zones, and

beyond (i.e., out to 2 to 2.5 km). Testing of the HF/M3 sonar has demonstrated a probability of single-ping detection above 95 percent within the LFA sonar mitigation and buffer zones for many marine mammals (Ellison and Stein 1999).

The SL required for the HF/M3 sonar to effectively detect marine mammals (and possibly sea turtles) out the combined mitigation/buffer zone of 2,000 yd under the most adverse oceanographic conditions (low echo return and high ambient noise) is on the order of 220 dB re: 1 µPa (rms) at 1 m. The Navy designed the HF/M3 sonar to be as benign as possible within the marine environment to minimize potential effects to marine mammals. These features include:

1. The HF/M3 sonar source frequency is greater than 30 kHz, which pushes its frequency band well away from the best hearing bandwidth of mysticetes, pinnipeds, and sea turtles, but within the best hearing bandwidth of odontocetes;
2. A duty cycle that is variable, but below ten percent;
3. A maximum HF/M3 sonar pulse with a duration of 40 milliseconds. Ridgway et al. (1997) and Schlundt et al. (2000b) reported that measured TTS in bottlenose dolphins for a 20 kHz, one-second pulse occurred at received levels of 193 to 196 dB. For a 30 kHz, 40-milliseconds pulse, the estimated range from the HF/M3 sonar of 193 dB received level would be 22 m (72 ft); and
4. A transmission loss that is very high because of the high frequency of the sound source.

With the exception of odontocetes, we do not expect most ESA-listed species will be able to detect and potentially respond to HF/M3. For odontecetes, an additional safety measure will include the HF/M3 sonar SLs would be ramped-up over a five minute period to alert any animals that are close to the sonar and provide them time to move away from the sound source. This would prevent the animal from being exposed to sound levels that could cause injury. Any behavioral disruptions of individuals resulting from exposure to HF/M3 sonar during ramp up that could cause the animal to move away from the sound source are expected to be minor and temporary. Given the short duration of potential exposure, the infrequency of this stressor, and the temporary nature of biological responses of marine mammals, ESA-listed species evaluated in this consultation are either not likely to respond or are not likely to respond in ways that could be of biological significance. Therefore, the potential effect of HF/M3 sonar on ESA-listed species is considered insignificant and is not likely to adversely affect ESA-listed marine mammals (and their corresponding critical habitat), sea turtles, and fishes.

4.2 Vessel Strike

Potential adverse effects to ESA-listed species could occur through ship strikes. Vessel strikes from commercial, recreational, and military vessels are known to affect large whales and have resulted in serious injury and occasional fatalities to cetaceans (Lammers et al. 2003; Douglas et al. 2008; Laggner 2009; Berman-Kowalewski et al. 2010; Calambokidis 2012). Records of collisions date back to the early 17th century, and the worldwide number of collisions appears to have increased steadily during recent decades (Laist et al. 2001; Ritter 2012).

Numerous studies of interactions between surface vessels and marine mammals have demonstrated that free-ranging marine mammals often, but not always (e.g., Mckenna et al. 2015), engage in avoidance behavior when surface vessels move toward them. It is not clear whether these responses are caused by the physical presence of a surface vessel, the underwater noise generated by the vessel, or an interaction between the two (Bryant et al. 1984; Bauer 1986; Watkins 1986a; Corkeron 1995; Wursig et al. 1998; Bejder et al. 1999; Au and Green 2000b; Félix 2001; Nowacek et al. 2001; Erbe 2002b; Magalhaes et al. 2002; Williams et al. 2002c; Lusseau 2003; Richter et al. 2003c; Goodwin and Cotton 2004; Scheidat et al. 2004; Amaral and Carlson 2005; Simmonds 2005; Bain et al. 2006; Lemon et al. 2006; Lusseau 2006; Bejder and Lusseau. 2008; Bejder et al. 2009). Several authors suggest that the noise generated during motion is probably an important factor (Evans et al. 1992; Blane and Jaakson 1994; Evans et al. 1994). Water disturbance may also be a factor. These studies suggest that the behavioral responses of marine mammals to surface vessels are similar to their behavioral responses to predators. Avoidance behavior is expected to be even stronger when the Navy is conducting training or testing activities (e.g., when active sonar or explosives are in use). The most vulnerable marine mammals are those that spend extended periods of time at the surface in order to restore oxygen levels within their tissues after deep dives (*e.g.*, the sperm whale). In addition, some baleen whales seem generally unresponsive to vessel sound, making them more susceptible to vessel collisions (Nowacek et al., 2004). These species are primarily large, slow moving whales.

Some researchers have suggested the relative risk of a vessel strike can be assessed as a function of animal density and the magnitude of vessel traffic (e.g., Fonnesbeck et al. 2008; Vanderlaan et al. 2008). Differences among vessel types also influence the probability of a vessel strike. The ability of any ship to detect a marine mammal and avoid a collision depends on a variety of factors, including environmental conditions, ship design, size, speed, and personnel, as well as the behavior of the animal. Vessel speed, size, and mass are all important factors in determining if injury or death of a marine mammal is likely due to a vessel strike. For large vessels, speed and angle of approach can influence the severity of a strike. For example, Vanderlaan and Taggart (2007) found that between vessel speeds of 8.6 and 15 knots, the probability that a vessel strike is lethal increases from 0.21 to 0.79. Large whales also do not have to be at the water's surface to be struck. Silber et al. (2010) found when a whale is below the surface (about one to two times the vessel draft), there is likely to be a pronounced propeller suction effect. This suction effect may draw the whale into the hull of the ship, increasing the probability of propeller strikes.

In addition to effects on marine mammals, several studies have reported live sea turtles with vessel strike injuries. This indicates that under some circumstances (e.g., very small vessels, slow moving vessels, or a partial vessel strike only grazing a fin or outer shell) vessel strike can result in non-lethal effects on sea turtles that neither strand nor are killed by the interaction. In order to calculate the total number of non-lethal vessel strikes in the action area, we reviewed the literature for reported occurrences of non-lethal vessel strikes. As reported in the literature, the

proportion of live sea turtles with non-lethal vessel strike injuries for most populations is around two to four percent (Norem 2005; Deem et al. 2006; Blumenthal et al. 2009; Denkinger et al. 2013), although for one population it was as high as 19 percent (Denkinger et al. 2013). The injuries observed in a population at any given point in time likely occurred over many years, since a turtle can exhibit signs of a non-lethal vessel strike injury for many years after the encounter. Thus, the proportion of a population that experiences a non-lethal vessel strike encounter in any given year (i.e. annual rate) would be much smaller than those reported with such an injury at any single point in time (i.e., a snapshot).

Furthermore, each of the ESA-listed fish species considered in this opinion are thought to spend at least some time in the upper portions of the water column where they may be susceptible to vessel strike. Oceanic whitetip sharks can be found at the ocean surface and down to at least 152 m deep, but most frequently stay between depths of 25.5 and 50 m (Carlson and Gulak 2012; Young et al. 2017). Tagging and diet studies indicate that adult and juvenile steelhead are surface oriented, spending most of their time in the upper portions of the water column (Daly et al. 2014). Walker et al. (2007) summarized information from a series of studies off British Columbia looking at the vertical distribution of steelhead and found the species spends 72 percent of its time in the top 1 m of the water column, with few movements below 7 m. Scalloped hammerhead sharks may occur in the upper portions of the water column as well. Though tagging studies indicate Giant manta rays are capable of descending to depths of hundreds of meters, they are also known to occur in surface waters and be susceptible to vessel strike (82 FR 3694).

However, during the 17 years (2002 through 2019) of MMPA incidental take authorizations and ESA section 7 consultations for SURTASS LFA sonar training and testing activities, a ship strike associated with the operation of the SURTASS LFA sonar vessels has never occurred. (Navy 2018a). The slow speed of travel, the design of the T-AGOS vessels, with the catamaran-type split hull shape, and enclosed propeller system, make the potential for ship strike unlikely. Further, since the visual observers that keep watch during routine vessel transit and maneuvering are also trained in the detection of marine species, the likelihood is increased that any marine mammal or sea turtle in the vessel's path during daylight hours would be detected. During SURTASS LFA sonar training and testing activities, the combination of slow (3 kt; 3.5 kph during sonar training and testing activities and 10 kt; 11.5 kph during transit) ship speeds and the three effective elements of the Navy's monitoring and mitigation program are expected to virtually eliminate the risk of ship strikes of cetaceans. For these reasons, we conclude that the likelihood of a SURTASS LFA sonar vessel striking an ESA-listed species is so low as to be discountable.

Overall, due to (1) the slow speed of the SURTASS LFA sonar vessels (3 kt; 3.5 kph during sonar training and testing activities and 10 kt; 11.5 kph during transit) and the ability of these species to move out of the way of such vessels; (2) the low densities of these species in the offshore areas where the vessels would be maneuvering; and (3) the Navy's monitoring and

mitigation program, we conclude that the likelihood of a SURTASS LFA sonar vessel striking ESA-listed marine mammals (and their corresponding critical habitat), sea turtles, and fishes is so low as to be discountable. Because the likelihood of a vessel strike is so low as to be discountable, vessel strike is not likely to adversely affect the ESA-listed species and their corresponding critical habitat considered in this opinion.

4.3 Vessel Discharge

Operation of the SURTASS LFA sonar vessels will result in discharges incidental to normal operations of a vessel. The International Convention for the Prevention of Pollution from Ships (MARPOL73/78) prohibits certain discharges of oil, noxious liquid substances, sewage, garbage, and air pollution from vessels within certain distances of the coastline. The Convention is implemented by the Act to Prevent Pollution from Ships (APPS; 33 U.S.C. §§1905-1915 et seq.), which establishes requirements for the operation of Navy vessels. The SURTASS LFA sonar vessels will operate in compliance with these requirements. Despite the precautionary measures taken by the Navy to ensure such incidents do not occur, it is possible for an unintentional and intentional discharge of pollutants to occur. Therefore, we evaluated the potential for a small pollutant discharge that could occur during project activities and impact ESA-listed species. While such discharges may affect certain water quality properties, trigger harmful algal blooms, and temporarily affect distributions and behaviors of ESA-listed species and their prey, the size, duration, and localized extent of such discharges from only four vessels, would likely be minor relative to the vast action area. Moreover, any pollutants discharged into the open ocean would likely dissipate quickly due mixing in the water column from wind and wave currents. Additionally, the Navy has instituted a “double-exchange” policy for surface vessel ballast tanks. All Navy surface vessels completely offload ballast water originating in a foreign port outside of 22 km (12 nmi) from shore and take on and discharge ‘clean sea water’ two times prior to entry within 22 km (12 nmi) of shore. The seawater then can be discharged within 22 km (12 nmi) of shore whenever ballast is no longer needed (E.P.A. 1999). This minimizes the likelihood that ballast water from SURTASS LFA sonar vessels will transfer invasive species. However, because of the open ocean environment in which the proposed action will occur, the duration and small spatial extent of such a spill, and the wide-ranging life histories and mobility of ESA-listed marine mammals, sea turtles and fishes that may occur in the action area, the effects of a small spill are considered insignificant for all ESA-listed species and their corresponding critical habitat. Therefore, we conclude that vessel discharge is not likely to adversely affect ESA-listed species and their corresponding critical habitat in the action area.

4.4 Entanglement

Entanglement can result in death or injury of marine mammals, sea turtles, and fishes (Moore et al. 2009; Van Der Hoop et al. 2013; Duncan et al. 2017). Towing HLA (horizontal line arrays used for SURTASS) presents a small risk of entanglement to ESA-listed species due to the long lines of the array. The passive, or listening, part of the SURTASS LFA sonar system is the SURTASS. This system detects returning echoes from submerged objects, such as threat

submarines, through the use of hydrophones. Part of the SURTASS transforms mechanical energy (received acoustic sound wave) to an electrical signal that can be analyzed by the processing system of the sonar. The SURTASS hydrophones are mounted on a receiver array (horizontal line array) that is towed astern of the vessel. The SURTASS LFA sonar vessel tows the hydrophone array at a minimum speed of 5.6 kph (3 kt) through the water to maintain the proper towed array geometry for maximum sonar system performance. The return signals, which are usually below background or ambient noise level, are then processed and evaluated to identify and classify potential underwater threats. The components of the passive sonar system could potentially strike or entangle ESA-listed species. However, the slow tow speed of the SURTASS LFA sonar vessel would provide sufficient time for a marine animal to move and avoid the SURTASS component if it were in close proximity, and it is highly unlikely that individuals would become struck or entangled. During the 17 years of MMPA Incidental Take Authorizations and ESA section 7 consultations for SURTASS LFA sonar training and testing activities, there have not been any ESA-listed species struck or entangled in the deployed equipment (C.Schroeder on behalf of the Navy, personal communication, January 31, 2019) (Navy 2018a). For these reasons, the likelihood of passive sonar components striking or becoming entangled with ESA-listed marine mammals, sea turtles, or fishes is discountable. Because this sonar system does not transmit energy into the marine environment and the likelihood of passive sonar components striking or entangling an ESA-listed species is discountable, we conclude that passive sonar components are not likely to adversely affect ESA-listed marine mammals (and their corresponding critical habitat), sea turtles, and fishes in the action area.

5 SPECIES AND CRITICAL HABITAT NOT LIKELY TO BE ADVERSELY AFFECTED

This section identifies the ESA-listed species and critical habitat under NMFS jurisdiction that may occur within the action area (as described in section 3.6) and may be affected but are not likely to be adversely affected by the proposed action. An action warrants a "may affect, not likely to adversely affect" finding when its effects are wholly beneficial, insignificant or discountable. Beneficial effects have an immediate positive effect without any adverse effects to the species or habitat. Beneficial effects are usually discussed when the project has a clear link to the ESA-listed species or its specific habitat needs and consultation is required because the species may be affected.

Insignificant effects relate to the size or severity of the impact and include those effects that are undetectable, not measurable, or so minor that they cannot be meaningfully evaluated. Insignificant is the appropriate effect conclusion when plausible effects are going to happen, but will not rise to the level of constituting an adverse effect. That means the ESA-listed species may be expected to be affected, but not harmed or harassed.

Discountable effects are those that are extremely unlikely to occur. For an effect to be discountable, there must be a plausible adverse effect (i.e., a credible effect that could result from

the action and that would be an adverse effect if it did impact a listed species), but it is very unlikely to occur.

NMFS uses two criteria to identify the ESA-listed species or critical habitat that are not likely to be adversely affected by the proposed action, as well as the effects of activities that are interrelated to or interdependent with the Federal agency's proposed action. The first criterion is exposure, or some reasonable expectation of a co-occurrence, between one or more potential stressors associated with the proposed activities and ESA-listed species or designated critical habitat. If we conclude that an ESA-listed species or designated critical habitat is not likely to be exposed to the proposed activities, we must also conclude that the species or critical habitat is not likely to be adversely affected by those activities.

The second criterion is the probability of a response given exposure. ESA-listed species or designated critical habitat that is exposed to a potential stressor but is likely to be unaffected by the exposure is also not likely to be adversely affected by the proposed action. We applied these criteria to the species ESA-listed in Table 11 and we summarize our results below.

In this section, we evaluate effects on several ESA-listed species and designated critical habitat that may be affected, but are not likely to be adversely affected, by the proposed action. For ESA-listed species and critical habitat, we focus specifically on stressors that are likely to adversely affect species and critical habitat. The effects of stressors associated with the proposed action that are not likely to adversely affect species and critical habitat were evaluated in Section 4. These stressors include vessel noise, vessel discharge, ship strike, passive sonar components, and HF/M3. The only identified stressor that may adversely affect ESA-listed species and critical habitat is SURTASS LFA sonar (See Section 8.1). The species potentially occurring within the action area that may be affected, but are not likely to be adversely affected, are listed in Table 11, along with their regulatory status, designated critical habitat, and recovery plan. Critical Habitat that is not likely to be adversely affected is presented in Table 12 since the species. Summaries explaining why each of these species and critical habitat are not likely to be adversely affected are provided in Sections 5.1 to 5.6.

Table 11. Threatened and endangered species potentially occurring in the SURTASS LFA action area that may be affected, but are not likely to be adversely affected.

Species	ESA Status	Critical Habitat	Recovery Plan
Marine Mammals – Cetaceans			
Humpback Whale (*Megaptera novaeangliae*) – Arabian Sea DPS	E – 81 FR 62259	-- --	11/1991
Taiwanese Humpback Dolphin (*Sousa chinensis taiwanensis*)	E – 83 FR 21182	-- --	-- --
Fishes			

Chinook Salmon (*Oncorhynchus tshawytscha)* – California Coastal ESU	T – 70 FR 37160	70 FR 52488	81 FR 70666
Chinook Salmon (*Oncorhynchus tshawytscha)* – Central Valley Spring-Run ESU	T – 70 FR 37160	70 FR 52488	79 FR 42504
Chinook Salmon (*Oncorhynchus tshawytscha)* – Lower Columbia River ESU	T – 70 FR 37160	70 FR 52629	78 FR 41911
Chinook Salmon (*Oncorhynchus tshawytscha)* – Puget Sound ESU	T – 70 FR 37160	70 FR 52629	72 FR 2493
Chinook Salmon (*Oncorhynchus tshawytscha)* – Sacramento River Winter-Run ESU	E – 70 FR 37160	58 FR 33212	79 FR 42504
Chinook Salmon (*Oncorhynchus tshawytscha)* – Snake River Fall-Run ESU	T – 70 FR 37160	58 FR 68543	80 FR 67386 (Draft)
Chinook Salmon (*Oncorhynchus tshawytscha)* – Snake River Spring/Summer Run ESU	T – 70 FR 37160	64 FR 57399	81 FR 74770 (Draft)
Chinook Salmon (*Oncorhynchus tshawytscha)* – Upper Columbia River Spring-Run ESU	E – 70 FR 37160	70 FR 52629	72 FR 57303
Chinook Salmon (*Oncorhynchus tshawytscha)* – Upper Willamette River ESU	T – 70 FR 37160	70 FR 52629	76 FR 52317
Chum Salmon (*Oncorhynchus keta*) – Columbia River ESU	T – 70 FR 37160	70 FR 52629	78 FR 41911
Chum Salmon (*Oncorhynchus keta*) – Hood Canal Summer-Run ESU	T – 70 FR 37160	70 FR 52629	72 FR 29121
Coho Salmon (*Oncorhynchus kisutch*) – Central California Coast ESU	E – 70 FR 37160	64 FR 24049	77 FR 54565
Coho Salmon (*Oncorhynchus kisutch*) – Lower Columbia River ESU	T – 70 FR 37160	81 FR 9251	78 FR 41911
Coho Salmon (*Oncorhynchus kisutch*) – Oregon Coast ESU	T – 73 FR 7816	73 FR 7816	81 FR 90780
Coho Salmon (*Oncorhynchus kisutch*) – Southern Oregon and Northern California Coasts ESU	T – 70 FR 37160	64 FR 24049	79 FR 58750
Giant Manta Ray (*Manta birostris*)	T – 83 FR 2916	-- --	-- --
Oceanic Whitetip Shark (*Carcharhinus longimanus*)	T – 83 FR 4153	-- --	-- --
Sakhalin Sturgeon (*Acipenser mikadoi*)	E – 79 FR 31222	-- --	-- --

Scalloped Hammerhead Shark (*Sphyrna lewini*) – Indo-West Pacific DPS	T – 79 FR 38213	-- --	-- --
Sockeye Salmon (*Oncorhynchus nerka*) – Ozette Lake ESU	T – 70 FR 37160	70 FR 52630	74 FR 25706
Sockeye Salmon (*Oncorhynchus nerka*) – Snake River ESU	E – 70 FR 37160	58 FR 68543	80 FR 32365
Steelhead Trout (*Oncorhynchus mykiss*) – California Central Valley DPS	T – 71 FR 834	70 FR 52487	79 FR 42504
Steelhead Trout (*Oncorhynchus mykiss*) – Central California Coast DPS	T – 71 FR 834	70 FR 52487	81 FR 70666
Steelhead Trout (*Oncorhynchus mykiss*) – Lower Columbia River DPS	T – 71 FR 834	70 FR 52629	78 FR 41911
Steelhead Trout (*Oncorhynchus mykiss*) – Middle Columbia River DPS	T – 71 FR 834	70 FR 52629	74 FR 50165
Steelhead Trout (*Oncorhynchus mykiss*) – Northern California DPS	T – 71 FR 834	70 FR 52487	81 FR 70666
Steelhead Trout (*Oncorhynchus mykiss*) – Puget Sound DPS	T – 72 FR 26722	81 FR 9251	-- --
Steelhead Trout (*Oncorhynchus mykiss*) – Snake River Basin DPS	T – 71 FR 834	70 FR 52629	81 FR 74770 (Draft)
Steelhead Trout (*Oncorhynchus mykiss*) – South-Central California Coast DPS	T – 71 FR 834	70 FR 52487	78 FR 77430
Steelhead Trout (*Oncorhynchus mykiss*) – Southern California DPS	E – 71 FR 834	70 FR 52487	77 FR 1669
Steelhead Trout (*Oncorhynchus mykiss*) – Upper Columbia River DPS	T – 71 FR 834	70 FR 52629	72 FR 57303
Steelhead Trout (*Oncorhynchus mykiss*) – Upper Willamette River DPS	T – 71 FR 834	70 FR 52629	76 FR 52317

5.1 Endangered Species Act- Listed Cetaceans

ESA-listed cetaceans including Indo-Pacific (Taiwanese) humpback dolphins and Arabian Sea DPS humpback whales may occur near the Navy's proposed action area for SURTASS LFA sonar training and testing activities. Indo-Pacific (Taiwanese) humpback dolphins are a medium sized delphinid species that occurs only off the west coast of Taiwan. They were designated as endangered on May 9, 2018, under the ESA due to their small population size, which is likely the result of pollution, habitat loss, underwater noise, and interactions with fisheries (Dungan et al. 2011). Indo-Pacific (Taiwanese) humpback dolphins have an extremely coastal range, only occurring out to 5.6 km (3 nmi) from shore (Dares et al. 2014; Dares et al. 2017). The Taiwanese humpback dolphin is a mid-frequency specialist meaning their hearing range falls between 150Hz to 160kHz (NMFS 2018a). Noise disturbance resulting from development-related

activities such as pile-driving, seismic research, and military exercises within its habitat may be threats to the health and well-being of the population (Whittaker and Young 2018). Like most odontocetes, Indo-Pacific (Taiwanese) humpback dolphins produce a variety of clicks and whistles. The maximum observed frequency range of whistles range from 520 Hz to 33 kHz, while echolocation clicks occur at higher frequencies of 43.5 to 142.1 kHz (Li et al. 2013; Wang et al. 2013; Wang et al. 2014). Based on these data, Indo-Pacific (Taiwanese) humpback dolphins are expected to have a maximum hearing range between frequencies of approximately 500 Hz to 145 kHz (Li et al. 2012; Li et al. 2013; Wang et al. 2014).

The humpback whale is a widely distributed baleen whale found in all major oceans. The Arabian Sea DPS includes those whales that are currently known to breed and feed along the coast of Oman (Bettridge et al. 2015). Nevertheless, historical records from the eastern Arabian Sea along the coasts of Pakistan and India indicate its range may also include these areas (Bettridge et al. 2015). The population was considered discrete based upon its unique breeding and feeding distribution which is geographically separated by other breeding distributions, and level of genetic differentiation from other populations. It was considered significant based upon the gap in both the range that would occur should the population become extinct, its unique ecological setting, and marked degree of genetic differentiation from other populations (Bettridge et al. 2015). Since 2017, two passive acoustic monitoring recordings, a tracked satellite tagged whale (tagged off the coast of Oman), and a single humpback stranding have been detected off the west coast of India (Madhusudhana et al. 2018; Sutaria 2018). Additionally, three humpback whale strandings in the late 1980s and early 1990s off the coast of Sri Lanka have occurred (Brownell et al. 2017). However, it is important to note that the majority of sightings and telemetry data show year-round occurrence of the Arabian Sea DPS of humpback off the coast of Oman (Minton et al. 2011). In terms of functional hearing capability, humpback whales belong to low frequency cetaceans which have a hearing range of 7 Hz to 22 kHz (Southall et al. 2007b). Humpback whale audiograms using a mathematical model based on the internal structure of the ear estimate sensitivity is from 700 Hz to 10 kHz, with maximum relative sensitivity between 2 kHz and 6 kHz (Ketten and Mountain 2014).

The Navy's SURTASS LFA sonar training and testing activities would occur no closer than 22 km (12 nmi) to shore with the proposed stand-off distance. Within shore of this standoff distance, the Navy would ensure sound levels would not exceed 180 dB re: 1 µPa (rms). Due to the narrow coastal ranges of the Indo-Pacific (Taiwanese) humpback (5.6 km [3 nmi] from shore) dolphins, and the Navy's proposed stand-off distance, it is highly implausible that Indo-Pacific (Taiwanese) humpback dolphin would be exposed to sound from SURTASS LFA sonar that would be above ambient sound levels. Exposure above ambient noise levels would only occur if Indo-Pacific (Taiwanese) humpback dolphins were to travel far offshore, outside of their typical range, at the same time and location where the Navy was operating SURTASS LFA sonar right at the 22 km (12 nmi) stand-off distance. In addition, recent studies on the characteristics of LFA sonar show that little acoustic energy is able to be propagated into the nearshore environment during LFA sonar operations (Marine Acoustics Inc. 2019). As a result, the

likelihood of SURTASS LFA sonar activities affecting Indo-Pacific (Taiwanese) humpback dolphins is very low.

In addition, due to the rare occurrences of Arabian Sea DPS humpback whales in the northwestern portion of the action area, there is a low probability that SURTASS LFA sonar training and testing activities would affect Arabian Sea DPS humpback whales. This probability is further reduced due to the low number of transmission hours that SURTASS LFA sonar will transmit in the model area closest to where Arabian Sea DPS humpbacks are found (i.e., the Sri Lanka model which is estimated to only be exposed to 17.8 transmission hours during the first four years of activity and 24.9 transmission hours during years five through seven; See Table 2) at a maximum duty cycle of 20 percent. As a result of this information, it is extremely unlikely that Arabian Sea DPS humpback whale would be affected by SURTASS LFA sonar training and testing activities.

Therefore, due to the reasons presented above, the potential effects of SURTASS LFA sonar training and testing activities on Arabian Sea DPS humpback whales and Indo-Pacific (Taiwanese) humpback dolphins are discountable. Thus, we conclude that the Navy's operation of SURTASS LFA sonar training and testing activities in the action area for the period of August 2019 and ongoing for the reasonably foreseeable future is not likely to adversely affect the Arabian Sea DPS humpback whales and Indo-Pacific (Taiwanese) humpback dolphins. As a result, Arabian Sea DPS humpback whales and Indo-Pacific (Taiwanese) humpback dolphins will not be carried forward in this opinion.

5.2 Endangered Species Act-Listed Salmonids

ESA-listed salmonids including all Chinook, chum, coho, and sockeye ESUs, and steelhead DPSs may occur in the action area during their ocean migrations. Data indicates that Chinook, coho, sockeye, and chum salmon, and steelhead may be found in SURTASS LFA sonar current model areas in the North Pacific Ocean (Myers et al. 1996; Myers et al. 2006; Masuda et al. 2015) (Pearcy and Fisher 1990; Fisher and Pearcy 1995; PFMC 2014) Bi et al. (2011) (Light et al. 1989; Daly et al. 2014; NMFS 2015b)). In addition, the best hearing range currently considered for salmonids (100 to 400 Hz) overlaps with SURTASS LFA sonar frequencies, indicating that they may be able to detect SURTASS LFA sonar if close enough to the source (Ladich and Fay 2013; Hawkins and Popper 2016).

Hastings et al. (1996) studied the effects of low frequency underwater sound on fish hearing. The authors exposed the teleost fish *Astronotus ocellatus* to sound of varying frequencies (60 or 300 Hz), duty cycles (20 percent or continuous), and intensity (100, 400, or 180 dB re: 1 µPa). The only treatment where the authors observed some limited damage to sensory hair cells was with one hour of continuous exposure at 300 Hz and 180 dB, but this result was inconsistent (the only damage that was observed was in four of five fish). The authors recommended caution if attempting to extrapolate this result to other species or other sound sources, and also suggested that damage would be even more limited with shorter term stimulation or if fish were free to leave the site of simulation. For the 2015 consultation on the Navy's Northwest Training and

Testing activities (NMFS 2015a), NMFS and the Navy developed sound exposure criteria for low frequency sonar for fish. Though SURTASS LFA sonar training and testing activities was not evaluated, for other low frequency sonar sources (i.e., low-frequency sources equal to 180 dB and up to 200 dB) it was determined that fish would need to be within one m (3.3 ft) of the sonar source in order to experience TTS.

A few studies have examined the effects of SURTASS LFA sonar and seismic airguns on non-auditory tissues of fishes (Popper 2005; Popper et al. 2007; Kane et al. 2010). The consensus from these studies is that neither source, despite being very intense, had any effect on non-auditory tissues. In all fishes, the swim bladder was intact after exposure, and in the one study that involved an expert fish pathologist (to ensure that the non-auditory tissues of the fish sacrificed were examined properly), there was no damage to tissues either at the gross or cellular levels (Popper et al. 2007; Kane et al. 2010; Popper et al. 2016). These studies provide the first direct evidence that exposure to SURTASS LFA sonar is not likely to cause death or damage to fishes. However, it must be cautioned, as done by Hastings et al. (1996), McCauley et al. (2003), Popper et al. (2007), and Kastelein et al. (2008) (among others) that all studies to date encompass a very limited number of species and extrapolation among species and to other sound sources (or even to other levels or durations of the same sound sources), must be done with extreme caution, at least until there are more data upon which to base any extrapolations. Other studies have similarly found no mortality resulting from exposure to high intensity sounds (McCauley et al. 2000b; McCauley et al. 2003; Popper 2005; Popper et al. 2007; Hastings and Carlson 2008; Kane et al. 2010). In contrast, one report by Turnpenny et al. (1994) suggested that sound exposure could produce substantial damage in caged fishes. However, reviews by subject matter experts found problems with this report and concluded that it did not appear to reflect the best available science on this issue. Also, effects from impact pile driving have been found to cause tissue damage in fishes (Halvorsen et al. 2012), however it should be noted that the differences in in the acoustic signal of each source (i.e. impulsive noise and broadband frequency from impact pile driving vs. continuous and narrowband frequency of SURTASS LFA sonar) illustrate that impacts from pile driving cannot be directly related to impacts from SURTASS LFA sonar.

Popper et al. (2007; 2008; Popper and Hastings 2009) investigated the effects of exposing several fish species, including a salmonid, to LFA sonar, focusing on the hearing and on non-auditory tissues. Their 2007 study exposed fishes to LFA sonar pulses for time intervals that would be substantially longer than what would occur in nature, but fishes did not experience mortalities or damage to body tissues at the gross or histological level. Some fish experienced temporary losses in hearing sensitivity, but they recovered within several days of exposure.

Halvorsen et al. (2013) conducted a series of experiments that exposed several fish species to high-intensity low-frequency naval sonar. This study experimented on largemouth bass, yellow perch, and channel catfish. In all, no effects on hearing were found in largemouth bass and yellow perch and only small effects in channel catfish (a fish with morphological adaptations for enhanced pressure reception).

Popper et al. (2014) also concluded that the risk of immediate mortality, mortal injury, or recoverable injury for fishes with swim bladders not involved in hearing exposed to low frequency sonar was low, regardless of the distance from the sound source. Low frequency sonar lacks the fast rise times, high peak pressures, and high acoustic impulse that could lead to mortality or injury in fishes.

Although exposure at such a short distance could result in hearing loss (Lombarte et al. 1993; Smith et al. 2006), ESA-listed salmonids in relatively close proximity to the LFA sonar source (e.g., within one m [3.3 ft] where TTS could occur) would likely move to actively avoid being within one meter of the source because they would likely perceive the sonar source as a potential predator or other threat. This would reduce the duration of exposure to the sound source, reducing the likelihood that any hearing impairment would occur. In addition, the ESA-listed salmonid species considered in this opinion lack hearing specializations, which further minimizes the likelihood of any instance of TTS from exposure to this sound source. As a result, there is a low probability SURTASS LFA activities will result in TTS for ESA-listed salmonids in the action area.

In addition to TTS, we also assessed the potential for exposure to SURTASS LFA sonar to result in behavioral responses in ESA-listed salmonids. There is a lack of studies that have investigated the behavioral reactions of unrestrained fishes to anthropogenic sound, especially in the natural environment. Studies of caged fishes have identified three basic behavioral reactions to sound: startle, alarm, and avoidance (Pearson et al. 1992; McCauley et al. 2000b). However, Popper et al. (2014) concluded that the relative risk of a fish exhibiting a behavioral response to low-frequency sonar was low, regardless of the distance from the sound source. Should an ESA-listed salmonid exhibit a behavioral response from exposure to low-frequency sonar, we do not expect these reactions to have any measurable effects of any individual's fitness. We expect individuals that exhibit a temporary behavioral response would return to pre-exposure behavior immediately following each exposure. Exposure time is expected to be brief because both the vessel and the individual fish are moving while in the ocean environment. Similar to instances of TTS described above, because these species are able to rely on alternative mechanisms for these essential life functions, instances of behavioral responses would not likely disrupt normal behavioral patterns, including breeding, feeding, or sheltering.

Therefore, due to the reasons presented above (i.e., i.e., low likelihood of TTS or behavioral impacts from SURTASS LFA sonar), the potential effects of SURTASS LFA sonar training and testing activities on ESA-listed salmonid species including all Chinook, chum, coho, and sockeye ESUs, and steelhead DPSs are insignificant. Thus, we conclude that the Navy's SURTASS LFA sonar training and testing activities in the action area for the period of August 2019 and ongoing for the reasonably foreseeable future is not likely to adversely affect ESA-listed salmonid species. As a result, ESA-listed salmonids will not be carried forward in this opinion.

5.3 Endangered Species Act-Listed Sturgeon

ESA-listed Sakhalin sturgeon may occur in the action area during their ocean migrations. Sakhalin sturgeon occurs only in the waters of the western North Pacific Ocean from the Sea of Japan (as far south as Hokkaido, Japan, and Wonsan, North Korea) north to the Bering Strait, including the Sea of Okhotsk, and associated rivers (P. Shmigirilov et al. 2007). Sakhalin sturgeon migrate into freshwater rivers to spawn, principally now only in the Tumnin River, but rare adults have been observed in the Viyakhtu and Koppi rivers, Russia (P. Shmigirilov et al. 2007). Japanese researchers believe the Sakhalin sturgeon to be extinct in Hokkaido, Japan (Omoto et al. 2005).

While sturgeon have swim bladders, they are not closely linked with the auditory system, making it unlikely for swim bladders to play a key role in hearing for sturgeon. Popper (2005) reported that studies measuring responses of the ear of European sturgeon (*Acipenser sturio*) using physiological methods suggest sturgeon are likely capable of detecting sounds from below 100 Hz to about 1 kHz. Meyer and Popper (2002) recorded auditory evoked potentials of varying frequencies and intensities for lake sturgeon (*Acipenser fulvescens*) and found that lake sturgeon can detect pure tones from 100 Hz to 2 kHz, with best hearing sensitivity from 100 to 400 Hz. Lovell et al. (2005) also studied sound reception and the hearing abilities of paddlefish (*Polyodon spathula*) (a closely related non-teleost actinopterygian) and lake sturgeon. Using a combination of morphological and physiological techniques, they determined that paddlefish and lake sturgeon were responsive to sounds ranging in frequency from 100 to 500 Hz, with the lowest hearing thresholds from frequencies in a bandwidth of between 200 and 300 Hz and higher thresholds at 100 and 500 Hz; lake sturgeon were not sensitive to sound pressure. We assume that the hearing sensitivities reported for these other species of sturgeon are representative of the hearing sensitivities of Sakhalin sturgeon.

The precise expected response of ESA-listed sturgeon to low-frequency acoustic energy is not completely understood due to a lack of sufficient experimental and observational data for this taxon. However, given the signal type and level of exposure to the low frequency signals used in SURTASS LFA sonar training and testing activities, and the fact that most sturgeon are found in nearshore, coastal, or freshwater areas, we do not expect frequent or prolonged exposure to this sound source. For more information on the impacts of LFA sonar on fishes with swim bladders, see Section 5.2. As with salmonids discussed above, the likelihood for TTS to develop in sturgeon as a result of SURTASS LFA activities would be very low due to the distance at which TTS is expected to occur (i.e., one m [3.3 ft]).

Based on the above review, it is likely that SURTASS LFA sonar could be audible to ESA-listed Sakhalin sturgeon, and as such, may elicit a behavioral response. However, Popper et al. (2014) concluded that the relative risk of a fish eliciting a behavioral response to low-frequency sonar was low, regardless of the distance from the sound source.

Additionally, as stated previously, Popper et al. (2014) concluded that behavioral reactions of fish in response to exposure to LFA sonar was unlikely, regardless of the distance from the

sound source. The most likely response of ESA-listed sturgeon exposed to LFA sonar, if any, would be minor temporary changes in behavior including increased swimming rate, avoidance of the sound source, or changes in orientation to the sound source, none of which rise to the level of take.

Therefore, due to the reasons presented above (i.e., low likelihood of TTS or behavioral impacts from SURTASS LFA sonar), the potential effects of SURTASS LFA sonar training and testing activities on Sakhalin sturgeon are insignificant. Thus, we conclude that the Navy's SURTASS LFA sonar training and testing activities in the action area for the period of August 2019 and ongoing for the reasonably foreseeable future is not likely to adversely affect Sakhalin sturgeon. As a result, Sakhalin sturgeon will not be carried forward in this opinion.

5.4 Endangered Species Act-Listed Elasmobranchs

ESA-listed elasmobranchs (giant manta ray, oceanic whitetip shark, and scalloped hammerhead shark) may occur in the action area. Populations for some species and DPSs (e.g., scalloped hammerhead sharks) are generally delineated by ocean basins based on discrete differences in genetic structure and limited transoceanic migrations of the species. Unless otherwise noted, the information presented below was obtained from status review reports and other ESA-listing documents (Table 11).

Elasmobranchs, like all fishes, have an inner ear capable of detecting sound waves and a lateral line capable of detecting particle motion caused by sound (Hastings and Popper 2005; Popper and Schilt 2009). Data for elasmobranchs fishes suggest detection of sounds from 20 Hz to 1 kHz with the highest sensitivity to sounds at lower ranges (Myrberg Jr. 2001; Casper et al. 2003; Casper and Mann 2006; Casper and Mann 2009; Casper et al. 2012; Ladich and Fay 2013). However, unlike most teleost fish, elasmobranchs do not have swim bladders, and thus are not likely capable of detecting sound pressure (Casper et al. 2012). Given their assumed hearing range, elasmobranchs are anticipated to be able to detect SURTASS LFA sonar if exposed. However, the duration and intensity of low-frequency acoustic stressors and the implementation of mitigation measures (described in section 3.1) will likely minimize the effect this stressor has on elasmobranchs. Furthermore, although some elasmobranchs have been known to respond to anthropogenic noise, in general elasmobranchs are not considered particularly sensitive to noise (Casper et al. 2012). This is described in detail from the examples provided below.

Several elasmobranch species, including the oceanic silky shark (*Carcharhinus falciformis*) and coastal lemon shark (*Negaprion brevirostris*), have been observed withdrawing from pulsed low-frequency sounds played from an underwater speaker (Myrberg et al. 1978; Klimley and Myrberg 1979). Lemon sharks exhibited withdrawal responses to pulsed low to mid-frequency sounds (500 Hz to 4 kHz) raised 18 dB at an onset rate of 96 dB per second to a peak amplitude of 123 dB received level from a continuous level, just masking broadband ambient noise (Klimley and Myrberg 1979). In the same study, lemon sharks withdrew from artificial sounds that included 10 pulses per second and 15 to 7.5 decreasing pulses per second.

In contrast, some elasmobranchs are attracted to pulsing low frequency sounds. Myrberg (2001) stated that sharks have demonstrated highest sensitivity to low frequency sound (40 to 800 Hz). Free-ranging sharks are attracted to sounds possessing specific characteristics including irregular pulsed, broadband frequencies below 80 Hz and transmitted suddenly without an increase in intensity, thus resembling struggling fish. Myrberg (2001) found that sudden onset, loud (20–30 dB above ambient noise levels) sounds played when a shark approached a location would result in startling the shark and it would turn away from the area. However, in most cases involving attraction and repelling, the sharks would habituate to the stimuli after a few trials.

These signals, some "pulsed," are substantially different from the SURTASS LFA sonar signals. Myrberg et al. (1978) reported that silky shark withdrew 10 m (33 ft) from a speaker broadcasting a 150 to 600 Hz sound with a sudden onset and peak SL of 154 dB. These sharks avoided a pulsed low frequency attractive sound when its sound level was abruptly increased by more than 20 dB. Other factors enhancing withdrawal were sudden changes in the spectral or temporal qualities of the transmitted sound. The pelagic oceanic whitetip (*Carcharhinus longimanus*) also showed a withdrawal response during limited tests, but less so than other species (Myrberg et al. 1978). These results do not rule out that such sounds may have been harmful to the fish after habituation; the tests were not designed to examine that point.

Popper et al. (2014) concluded that the relative risk of a fishes with no swim bladders exhibiting a behavioral response to LFA sonar was low, regardless of the distance from the sound source. Popper et al. (2014) also concluded that the risk of mortality, mortal injury, or recoverable injury for fish with no swim bladders exposed to LFA sonar was low, regardless of the distance from the sound source.

The precise expected response of ESA-listed elasmobranchs to low-frequency acoustic energy is not completely understood due to a lack of sufficient experimental and observational data for these species and DPSs. However, given the signal type and level of exposure to the low frequency signals used in SURTASS LFA sonar training and testing activities, we do not expect TTS, injury, or mortality to occur for these species. Additionally, as stated previously, Popper et al. (2014) concluded that behavioral reactions of fish in response to exposure to LFA sonar were unlikely, regardless of the distance from the sound source. However, since LFA sonar emits frequencies within the hearing ranges of elasmobranchs, should they detect it, the most likely response of ESA-listed elasmobranchs exposed to LFA sonar, if any, would be minor temporary changes in their behavior including increased swimming rate, avoidance of the sound source, or changes in orientation to the sound source, none of which rise to the level of take. These minor responses are expected to be short term and quickly return to normal after the brief exposure to the sound source.

Therefore, the potential effect of SURTASS LFA sonar training and testing activities on ESA-listed elasmobranch species is insignificant. We conclude that the Navy's operation of SURTASS LFA sonar in the action area for the period of August 2019 and ongoing for the reasonably foreseeable future is not likely to adversely affect ESA-listed elasmobranch species

and DPSs. As a result, ESA-listed elasmobranchs (giant manta ray, oceanic whitetip shark, and scalloped hammerhead shark) will not be carried further in this opinion.

5.5 Hawaiian Monk Seal Critical Habitat

Hawaiian monk seal critical habitat was originally designated on April 30, 1986 (51 FR 16047) and was extended on May 26, 1988 (53 FR 18988) (Table 12). It includes all beach areas, sand spits, and islets (including all beach crest vegetation to its deepest extent inland), lagoon waters, inner reef waters, and ocean waters out to a depth of 37 m (121.4 ft) around the northwestern Hawaiian Islands breeding atolls and islands. On September 21, 2015, NMFS published a final rule to revise designated critical habitat for Hawaiian monk seals (80 FR 50925), extending the current designation in the northwestern Hawaiian Islands out to the 200 m (656.2 ft) depth contour (including Kure Atoll, Midway Islands, Pearl and Hermes Reef, Lisianski Island, Laysan Island, Maro Reef, Gardner Pinnacles, French Frigate Shoals, Necker Island, and Nihoa Island). It also designated six new areas in the main Hawaiian Islands (i.e., terrestrial and marine habitat from 5 m [16.4 ft] inland from the shoreline extending seaward to the 200 m (656.2 ft) depth contour around Kaula, Niihau, Kauai, Oahu, Maui, Nui, and Hawaii). Only the marine portion of designated Hawaiian monk seal critical habitat, which includes the seafloor plus waters 10 m (33 ft) above seafloor off the Main and Northwest Hawaiian Islands from depths of 80 to 200 m (262.5 to 656.2 ft), occurs near the action area and thus may be affected by the proposed action (Figure 3).

In addition, certain areas have been excluded from the Hawaiian monk seal's critical habitat because they are managed under and military Integrated Natural Resources Plans. These areas in the Hawaiian Islands include: 1) Marine Corps Base Hawaii, Oahu—a 500-yd (91 m) buffer zone in the waters surrounding the base and the Puuloa Training Facility on the Ewa coastal plain, Oahu; 2) Joint Base Pearl Harbor-Hickam, Oahu inclusive of Nimitz Beach, White Plains Beach, Naval Defensive Sea Area, Barbers Point Underwater Range, and Ewa Training Minefield; 3) Pacific Missile Range Facility, Kauai, Offshore Areas plus Kaula Island and the coastal and marine areas to the 33 ft (10-m) isobath surrounding the Island of Niihau; 4) Kingfisher Underwater Training area, off the northeast coast of Niihau; 5) Puuloa Underwater Training Range off Pearl Harbor, Oahu; and 6) Shallow Water Minefield Sonar Training Range, off the western coast of Kahoolawe in the Maui Nui area (NOAA, 2015c).

The physical or biological features of the Hawaiian monk seal critical habitat that support the species' life history needs include 1) Terrestrial areas and adjacent shallow, sheltered aquatic areas with characteristics preferred by monk seals for pupping and nursing 2) Marine areas from 0 to 200 m in depth that support adequate prey quality and quantity for juvenile and adult monk seal foraging3) Significant areas used by monk seals for hauling out, resting, or molting

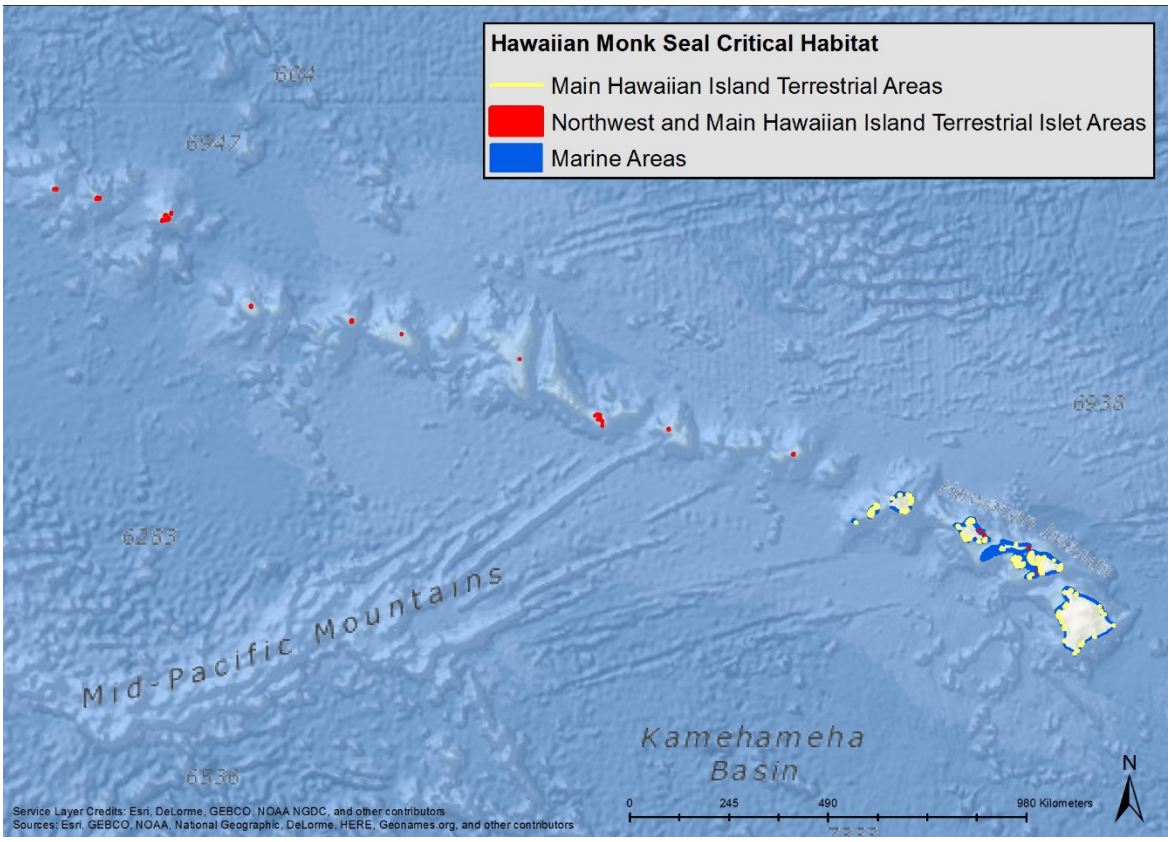

Figure 3. Map identifying designated critical habitat in the Northwest Hawaiian Islands and Main Hawaiian Islands for the endangered Hawaiian monk seal.

As discussed earlier and later in Section 8.1 and Section 8.1.1, the only identified stressor that may adversely affect ESA listed species and/or critical habitat is SURTASS LFA sonar. However, nearly all of the critical habitat for the Hawaiian monk seal lies within the coastal standoff distance for SURTASS LFA sonar. A small area of the Hawaiian monk seal's critical habitat at Penguin Bank extends beyond the 22-km (12-nmi) coastal standoff distance, but it is fully located within the existing Penguin Bank, Hawaiian Islands Humpback Whale NMS (OBIA 16; See Table 5). Thus, the entire critical habitat is covered by some form of geographic mitigation which means it cannot be exposed to LFA sonar sounds greater than 180 dB re: 1 µPa (rms) (or lower in the OBIA, given the 1km buffer outside the perimeter of the OBIA). Nevertheless, LFA sonar (less than 180 dB re: 1 µPa (rms)) may affect marine areas with adequate prey quantity and quality on the external boundaries of the critical habitat.

Based upon our discussion of LFA sonar on fishes described previously, we do not anticipate these stressors will adversely affect fish prey species in CH for the same reasons. In addition to fish, a range of invertebrates are reported to be sensitive to low-frequency (10 to 150 Hz) hydroacoustic disturbances induced by sound waves or other sources – e.g., jellyfish, crustaceans, arrow worms, octopus, and squid (Western Australian Department of Industry and Resources 2002; Albert 2011; Sole et al. 2016). This sensitivity overlaps the frequency range of SURTASS LFA sonar (100 to 500 Hz), indicating that some mobile invertebrates could perceive

SURTASS LFA sonar training and testing activities (Western Australian Department of Industry and Resources 2002; Albert 2011; Sole et al. 2016). Available studies report responses to airgun shots as being limited to transient alarm responses such as tail-flicks (lobsters) or siphon closing (ascidians) (Western Australian Department of Industry and Resources 2002), although mortality of giant squid in the Bay of Biscay may have been linked to seismic airgun activity in the area (Guerra *et al.* 2004). In addition, at least some jellyfish species appear to experience acoustic trauma as the result of exposure to low frequency sonar at frequencies between 50 to 400 Hz and at received levels up to 175 dB re: 1 µPa (rms) (Sole et al. 2016).

There are studies examining the effects of low frequency sounds on copepods, which are not direct prey of Hawaiian monk seals but may impact the monk seal's food chain (Weijerman et al. 2017). One study documented no significant effects to copepod density, recruitment, and mortality from low frequency sounds (Bennet et al. 1994). However, recent evidence indicates that seismic airgun arrays may lead to a significant reduction in zooplankton, including copepods. McCauley et al. (2017) found that the use of a single airgun lead to a decrease in zooplankton abundance by over 50 percent and a two- to three-fold increase in dead adult and larval zooplankton when compared to control scenarios. In addition, effects were found out to 1.2 kilometers (0.6 nautical miles), the maximum distance to which the sonar equipment used in the study was able to detect changes in abundance. Richardson et al. (2017) scaled up the results of McCauley et al. (2017) to examine the effects of a hypothetical seismic survey on zooplankton off the coast of Australia. Based on their results, seismic surveys had a significant impact on the abundance of zooplankton within and near the seismic survey area, but such effects were short-lived and minimized by ocean circulation. Nevertheless, it is important to note that there are substantial differences in the acoustic characteristics between low frequency, broadband impulsive sound from seismic airguns and continuous sound from SURTASS LFA sonar.

Mooney et al. (2016) reported on the results of a behavioral study that showed one species of squid possessed optimal hearing in the range from 200 to 400 Hz, with responses to 80 Hz. Behavioral responses to sound stimuli included escape and predator avoidance behaviors. These responses included inking (which occurred at the lowest sound frequencies and highest sound levels), body color changes, and jetting) (Mooney et al. 2016). Common cuttlefish respond behaviorally to sounds below 1000 Hz (maximum sensitivities near 150 Hz), with escape responses (inking, jetting) observed between 80 and 300 Hz, sound levels above 140 dB re 1 µPa (rms), and particle acceleration of 0.01 msec-2; body pattern changes and fin movements were observed at exposures from 80 to 1000 Hz, sound pressure levels of 85 to 188 dB re 1 µPa (rms), and particle accelerations of 0 to 17.1 msec-2 (Samson et al. 2014).

These studies and the studies mentioned in previous sections of this consultation indicate that exposure to low frequency sound such as LFA sonar, has limited potential to affect fishes and invertebrates. However, available evidence does not suggest low-frequency non-impulsive sound sources would typically be expected to cause mortality or physiological damage. Additionally, as indicated by Popper et al. (2014), the relative risk of a fish exhibiting a behavioral reaction in

response to low-frequency sonar is low, regardless of the distance from the sound source. Though squid and some other invertebrates appear to exhibit alarm responses and avoidance of sound sources, individuals would be expected to resume normal behaviors immediately after initial exposure.

Since availability of prey species is the only physical or biological feature of Hawaiian monk seal critical habitat that could be impacted by LFA sonar, we conclude that the Navy's operation of SURTASS LFA sonar in the action area for the period of August 2019 and ongoing for the reasonably foreseeable future is not likely to adversely affect designated Hawaiian monk seal critical habitat. Based on the evidence presented above, the potential effect of SURTASS LFA sonar training and testing activities on the abundance of prey species in Hawaiian monk seal critical habitat species is insignificant and would not likely affect the conservation value of the critical habitat. As such, we will not discuss Hawaiian monk seal critical habitat further in this consultation.

5.6 Critical Habitat for the Main Hawaiian Islands Insular Distinct Population Segment of the False Killer whale

Critical habitat designation for the Main Hawaiian Islands Insular DPS of false killer whale was published on July 24, 2018 (83 FR 35062). The rule designated waters from the 45-meter depth contour to the 3,200-meter depth contour around the main Hawaiian Islands from Ni'ihau east to Hawaii (Figure 4). This designation does not include most bays, harbors, or coastal in-water structures. As shown in Figure 4, 14 areas were excluded from this critical habitat designation (one area, with two sites, for the Bureau of Ocean Energy Management and 13 areas requested by the Navy). These areas were omitted because it was determined that the benefits of exclusion outweigh the benefits of inclusion, and exclusion will not result in extinction of the species. Additionally, the Ewa Training Minefield and the Naval Defensive Sea Area are precluded from designation under section 4(a)(3) of the ESA because they are managed under the Joint Base Pearl Harbor-Hickam Integrated Natural Resource Management Plan that NMFS deems a benefit to the main Hawaiian Islands insular false killer whale.

The designated critical habitat includes a single physical or biological feature essential for conservation of the species, island-associated marine habitat for the species with the following four characteristics that support that feature:

- Adequate space for movement and use within shelf and slope habitat.
- Prey species of sufficient quantity, quality, and availability to support individual growth, reproduction, and development, as well as overall population growth.
- Waters free of pollutants of a type and amount harmful to MHI IFKWs.
- Sound levels that would not significantly impair false killer whales' use or occupancy.

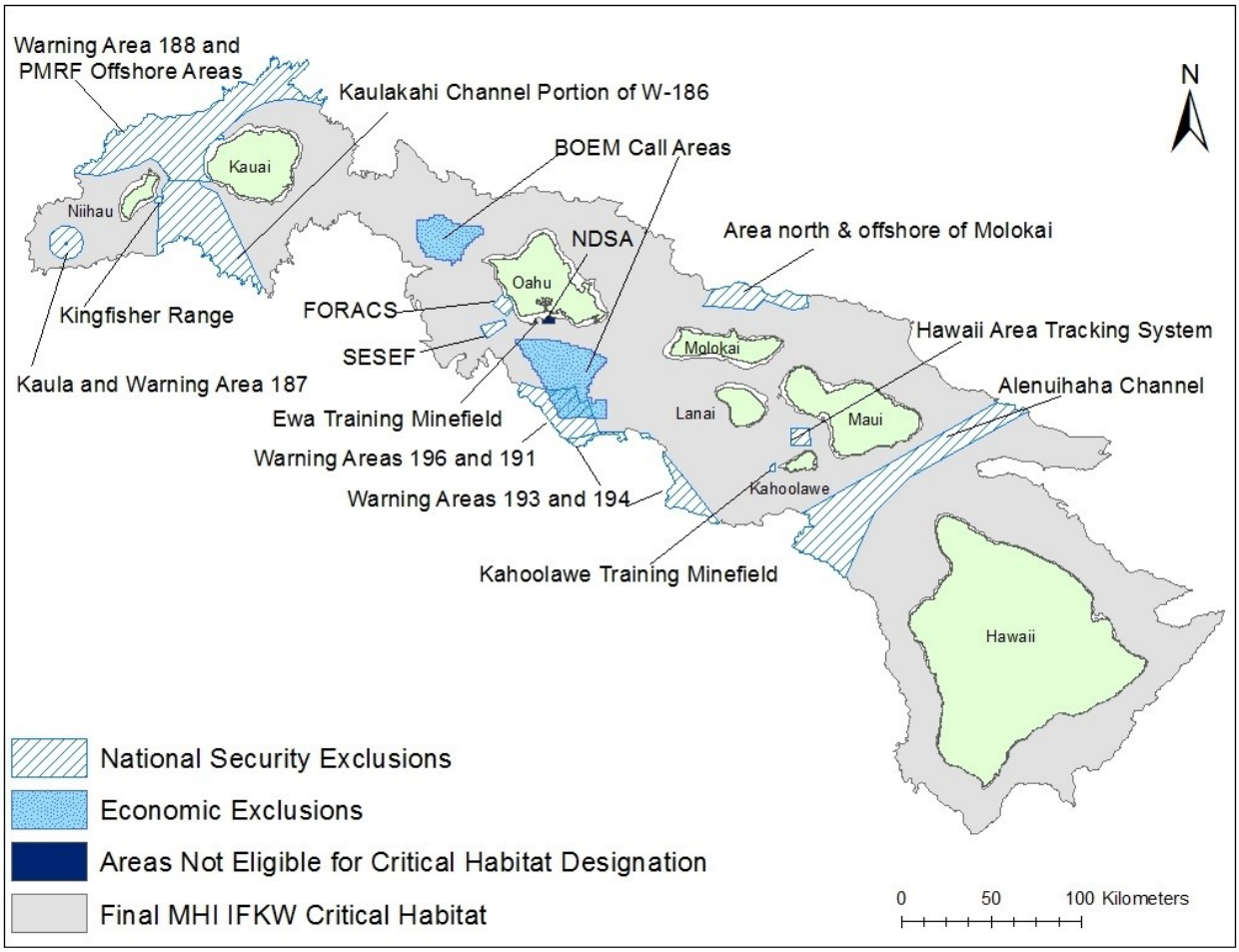

Figure 4. Map identifying designated critical habitat for the Main Hawaiian Islands Insular Distinct Population Segment of the False Killer Whale

The final rule to designate critical habitat identified several activities that may threaten the physical or biological features essential to conservation such that species management considerations or protections may be required. Major categories of activities included in the final rule were (1) in-water construction (including dredging); (2) energy development (including renewable energy projects); (3) activities that affect water quality; (4) aquaculture/mariculture; (5) fisheries; (6) environmental restoration and response activities (including responses to oil spills and vessel groundings, and marine debris clean-up activities); and (7) some military readiness activities.

A large portion of the Main Hawaiian Island Insular false killer whale critical habitat is within the coastal standoff range for SURTASS LFA sonar activities. However, in areas of the waters surrounding the Main Hawaiian Islands, some of the critical habitat is beyond the costal standoff range (i.e., the coastal standoff range for SURTASS LFA (12 nmi (22 km)) sonar is located closer to shore than the seaward boundary of the critical habitat for the Main Hawaiian Island Insular false killer whale). In addition, part of the Coastal Zone Management Act (CZMA)

stipulations for SURTASS LFA sonar use in Hawaiian waters required the Navy to agree not to use SURTASS LFA sonar in state waters (out to 3 nmi) or within Penguin Bank to a water depth of 600 ft (183 m) and to limit ensonification within Hawaii state waters to 145 dB re: 1 µPa rms. This includes some of the critical habitat, but a portion of the critical habitat lies beyond, or in deeper waters than the CZMA boundaries and coastal standoff range (equating to approximately 19,465.44 km^2). As a result, less than 40 percent of the Main Hawaiian Island Insular false killer whale critical habitat has the potential to be exposed to SLs greater than 180 dB re: 1 µPa (rms).

In addition to the information presented above, the Main Hawaiian Islands OBIA, which encompasses a large portion of false killer whale critical habitat outside of the coastal standoff range, and CZMA boundaries will be effective from November to April. During this time, SLs greater than 180 dB re: 1 µPa (rms) at 1 km from the Main Hawaiian Islands OBIA will not take place. As a result, less than 7,967 km^2 of false killer whale critical habitat (equating to 17 percent of the critical habitat) could be exposed to SURTASS LFA sonar SLs greater than 180 dB re: 1 µPa (rms) from November to April.

In reviewing the physical or biological features associated with the Main Hawaiian Island Insular false killer whale, island-associated marine habitat, it was concluded that LFA sonar may affect the following two physical or biological features:

- Marine areas with adequate prey quantity and quality; and
- Sound levels that would not significantly impair false killer whales' use or occupancy

Main Hawaiian Island Insular False killer whale prey may include various tuna species, marlin species, jack species, mahi mahi, wahoo, moonfish, and squid (NMFS 2018d). Recent stomach content analysis from Main Hawaiian Island Insular False killer whales that stranded from 2010-2016 has detected seven genus of fish and four species of cephalopods. Of those, diamondback squid (*Thysanoteuthis rhombus*) were the most common prey item. As discussed in Section 5.5, SURTASS LFA sonar's impact on fish and invertebrate prey species such as these will be insignificant.

In the final rule designating Main Hawaiian Islands insular false killer whale critical habitat, NMFS describes how sound levels are an important attribute of the island-associated habitat that is essential to the Main Hawaiian Islands Insular false killer whales' conservation. The rule states that it is important to consider "how chronic and persistent noise sources may alter the value of that habitat," and that the "mere presence of noise, or even noise which might cause harassment of the species, does not necessarily result in adverse modification." Regarding the characteristic specific to sound levels, the final rule to designate critical habitat defined these sound levels as those that inhibit Main Hawaiian Islands insular false killer whales' "*…ability to receive and interpret sound for the purposes of navigation, communication, and detection of predators and prey. Such noises are likely to be long-lasting, continuous, and/or persistent in the marine environment and, either alone or added to other ambient noises, significantly raise local sound levels over a significant portion of an area*" (83 FR 35062). The final biological report

developed in support of the final critical habitat rule discussed the complexity of analyzing how human activities may change an animal's use of an area (NMFS 2018d). The biological report emphasized that "…*the duration of the offending or masking noise will determine whether the effects or degradation to the habitat may be temporary or chronic, and whether such alterations to the soundscape may alter the conservation value of that habitat*" (NMFS 2018d).

To evaluate if effects of LFA sonar on Main Hawaiian Islands false killer whale critical habitat creates sound levels that would significantly impair false killer whales' use or occupancy of the critical habitat we consider four main criteria presented in the final rule designating the critical habitat. This includes the degree to which the noise may impede the false killer whales' ability to use the habitat for foraging, navigating, and communicating, or whether the noise sources may deter the population from using the habitat entirely (NMFS 2018d).

As stated in Section 3, the SURTASS LFA sonar transmission hours represent a distribution across six activities that include:

- Contractor crew proficiency training (80 hours per year)
- Military crew (MILCREW) proficiency training (96 hours per year)
- Participation in or support of Navy exercises (96 hours per year)
- Vessel and equipment maintenance (64 hours per year)
- Acoustic research testing (160 hours per year)
- New SURTASS LFA sonar system testing (96 hours per year; would occur in year 5 and beyond)

A subset of these activities could occur within designated critical habitat for Main Hawaiian Islands Insular false killer whale or result in sound that propagates into critical habitat. As shown in Table 2, the transmission hours from each of these activities will further be divided by the number of model areas the activity will occur in. In all, the annual estimated amount of SURTASS LFA sonar transmission hours that will occur in both the North and South Hawaii model areas totals to approximately 47 annual transmission hours from years 1 through 4 and 60 annual transmission hours from years 5 through 7. In addition, as discussed above, only 40 percent of the main Hawaiian Islands insular false killer whale critical habitat lies beyond the spatial extent of the coastal standoff range for SURTASS LFA sonar and the Hawaii CZMA boundaries for Penguin Bank, meaning that sound levels will be lower than 180 dB at the coastal standoff boundary, and increasingly lower moving closer towards shore. Also, from November to April only 17 percent of false killer whale critical habitat could be exposed to SLs exceeding 180 dB re 1 μPa (rms) as a result of the Main Hawaiian Islands OBIA. Further, due to the low number of transmission hours within the geographic range for Main Hawaiian Islands Insular false killer whales, it is estimated that the 40 percent of critical habitat that could be exposed to sound levels above 180 dB re 1 μPa (rms) (during April to November) would only be exposed to these sounds for a short period of time. Further, due to the low number of transmission hours

within the geographic range for Main Hawaiian Islands Insular false killer whales, only a small number of the Main Hawaiian Islands Insular DPS false killer whales are estimated to be harassed by SURTASS LFA sonar activities. Table 8 and Table 9 show that only one individual will experience MMPA Level B harassment from SURTASS LFA sonar activities per year. Due to the ephemeral exposures of LFA sonar on Main Hawaiian Islands Insular false killer whale critical habitat and the low number of annual takes of false killer whales throughout the entire action area, there is a discountable possibility that one of these annual takes will occur within designated critical habitat. As a result, LFA sonar impacts on Main Hawaiian Islands Insular false killer whale critical habitat is expected to be temporary with little potential for it to impact Main Hawaiian Islands Insular false killer whales within the critical habitat itself. As a result, SURTASS LFA sonar is not considered a chronic and persistent noise threat for Main Hawaiian Islands Insular false killer whale critical habitat.

Last, false killer whales are mid-frequency specialists. The general hearing sensitivity of false killer whales range between 2 to 115 kHz, with best sensitivity found between 16 and 24 kHz, and their echolocation clicks are centered around 40 kHz (Kloepper et al., 2010; Yuen et al., 2005; Thomas et al. 1988). Therefore, the frequencies produced by SURTASS LFA sonar are outside the general hearing range of false killer whales and are additionally well below their frequencies of best hearing sensitivity and echolocation.

In all, we conclude that the Main Hawaiian Islands Insular false killer whale critical habitat will not be adversely affected by the proposed action. This is due to the short duration of the potential exposure, the reduced area for potential exposure to occur (due to geographic mitigation), the expected minor effects to prey species, the primary hearing frequency of false killer whales, and low number of takes estimated for Main Hawaiian Island false killer whales. Due to these reasons, we expect that the effects would be insignificant, and would not affect the conservation value of the critical habitat. As a result, we conclude that the Navy's operation of SURTASS LFA sonar in the action area for the period of August 2019 and ongoing for the reasonably foreseeable future is not likely to adversely affect designated Main Hawaiian Island Insular false killer whale critical habitat. As such, we will not discuss Main Hawaiian Island Insular false killer whale critical habitat further in this consultation.

6 STATUS OF ENDANGERED SPECIES ACT-LISTED SPECIES LIKELY TO BE ADVERSELY AFFECTED BY THE PROPOSED ACTION

This section examines the status of each species that would be affected by the proposed action. The status includes the existing level of risk that the ESA-listed species face, based on parameters considered in documents such as recovery plans, status reviews, and listing decisions. The species status section helps to inform the description of the species' current "reproduction, numbers, or distribution," which is part of the jeopardy determination as described in 50 C.F.R. §402.02. More detailed information on the status and trends of these ESA-listed species, and their biology and ecology can be found in the listing regulations and critical habitat designations

published in the Federal Register, status reviews, recovery plans, and on these NMFS Web sites: https://www.fisheries.noaa.gov/protecting-marine-life. No designated critical habitat is likely to be adversely affected during SURTASS LFA sonar training and testing operations.

Table 12. Threatened and endangered species that are likely to be affected by the Navy's proposed SURTASS LFA activities.

Species	ESA Status	Critical Habitat	Recovery Plan
Marine Mammals – Cetaceans			
Blue Whale (*Balaenoptera musculus)*	E – 35 FR 18319	-- --	07/1998
Fin Whale (*Balaenoptera physalus)*	E – 35 FR 18319	-- --	75 FR 47538
Gray Whale (*Eschrichtius robustus*) Western North Pacific Population	E – 35 FR 18319	-- --	-- --
Humpback Whale (*Megaptera novaeangliae*) – Western North Pacific DPS	E – 81 FR 62259	-- --	11/1991
North Pacific Right Whale (*Eubalaena japonica*)	E – 73 FR 12024	73 FR 19000	78 FR 34347 06/2013
Sei Whale (*Balaenoptera borealis*)	E – 35 FR 18319	-- --	12/2011
False Killer Whale (*Pseudorca crassidens*) – Main Hawaiian Islands Insular DPS	E – 77 FR 70915	83 FR 35062	-- --
Sperm Whale (*Physeter macrocephalus*)	E – 35 FR 18319	-- --	75 FR 81584 12/2010
Marine Mammals – Pinnipeds			
Hawaiian Monk Seal (*Neomonachus schauinslandi*)	E – 41 FR 51611	80 FR 50925	72 FR 46966 2007
Spotted Seal (*Phoca largha*) – Southern DPS	T – 75 FR 65239	-- --	-- --
Steller Sea Lion (*Eumetopias jubatus*) – Western DPS	E – 55 FR 49204	58 FR 45269	73 FR 11872 2008
Sea Turtles			
Green Turtle (*Chelonia mydas*) – Central North Pacific DPS	T – 81 FR 20057	-- --	63 FR 28359
Green Turtle (*Chelonia mydas*) – East Indian-West Pacific DPS	T – 81 FR 20057	-- --	-- --
Green Turtle (*Chelonia mydas*) – North Indian DPS	T – 81 FR 20057	-- --	-- --
Green Turtle (*Chelonia mydas*) – Central West Pacific DPS	E – 81 FR 20057	-- --	63 FR 28359
Hawksbill Turtle (*Eretmochelys imbricata)*	E – 35 FR 8491	63 FR 46693	57 FR 38818

Species	ESA Status	Critical Habitat	Recovery Plan
			08/1992 – U.S. Caribbean, Atlantic, and Gulf of Mexico 63 FR 28359 05/1998 – U.S. Pacific
Leatherback Turtle (*Dermochelys coriacea*)	E – 35 FR 8491	44 FR 17710 and 77 FR 4170	10/1991 – U.S. Caribbean, Atlantic, and Gulf of Mexico 63 FR 28359 05/1998 – U.S. Pacific
Loggerhead Turtle (*Caretta caretta*) – North Indian Ocean DPS	E – 76 FR 58868	-- --	-- --
Loggerhead Turtle (*Caretta caretta*) – North Pacific Ocean DPS	E – 76 FR 58868	-- --	63 FR 28359
Olive Ridley Turtle (*Lepidochelys olivacea*) All Populations Except Mexico's Pacific Coast Breeding Colonies	T – 43 FR 32800	-- --	-- --

6.1 Blue Whale

The blue whale is a widely distributed baleen whale found in all major oceans (Figure 5). Blue whales are the largest animal on earth and distinguishable from other whales by a long-body and comparatively slender shape, a broad, flat "rostrum" when viewed from above, proportionally smaller dorsal fin, and are a mottled gray color that appears light blue when seen through the water. Most experts recognize at least three subspecies of blue whale, *B. m. musculus*, which occurs in the Northern Hemisphere, *B. m. intermedia*, which occurs in the Southern Ocean, and *B. m. brevicauda*, a pygmy species found in the Indian Ocean and South Pacific Ocean. The blue whale was originally listed as endangered on December 2, 1970 (Table 12).

Information available from the recovery plan (NMFS 1998), recent stock assessment reports (Muto et al. 2017; Hayes et al. 2018; Carretta et al. 2019), and status review (COSEWIC 2002) were used to summarize the life history, population dynamics, and status of the species as follows.

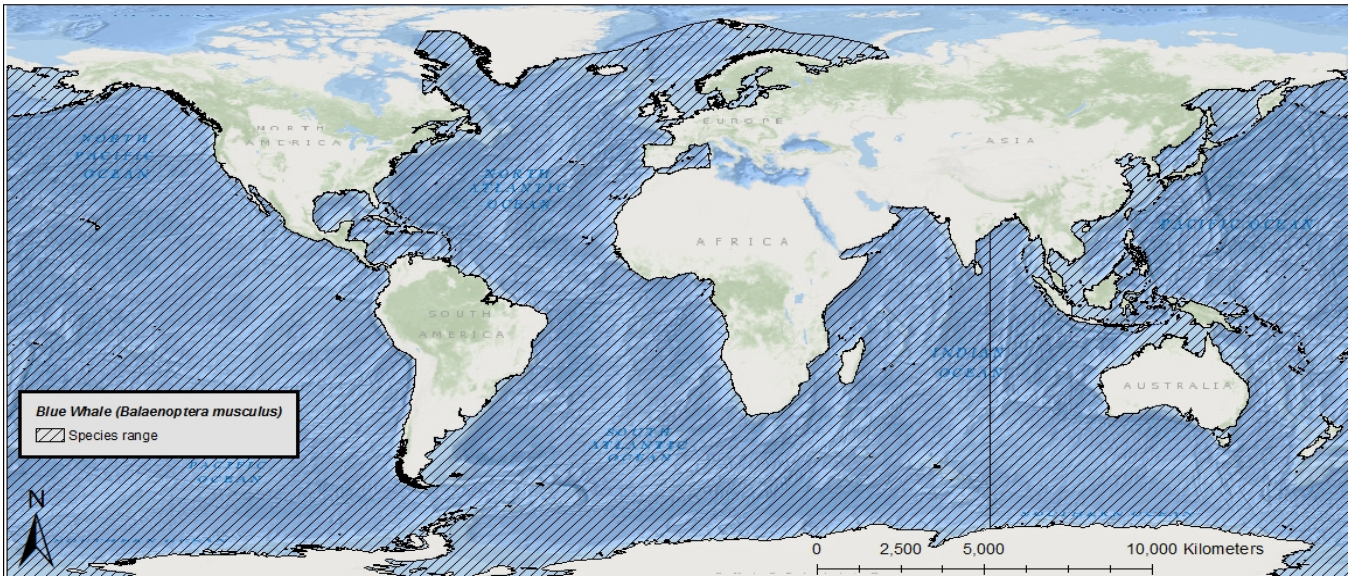

Figure 5. Map identifying the range of the endangered blue whale.

Life History

The average life span of blue whales is 80 to 90 years. They have a gestation period of ten to twelve months, and calves nurse for six to seven months. Blue whales reach sexual maturity between five and fifteen years of age with an average calving interval of two to three years. They winter at low latitudes, where they mate, calve and nurse, and summer at high latitudes, where they feed. Blue whales forage almost exclusively on krill and can eat approximately 3,600 kg (7,936.6 lb) daily. Feeding aggregations are often found at the continental shelf edge, where upwelling produces concentrations of krill at depths of 90 to 120 m (295.3 to 393.7 ft).

Population Dynamics

The following is a discussion of the species' population and its variance over time. This section includes abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the blue whale.

The global, pre-exploitation estimate for blue whales is approximately 181,200 (IWC 2007). Current estimates indicate approximately 5,000 to 12,000 blue whales globally (IWC 2007). Blue whales are separated into populations by ocean basin in the North Atlantic Ocean, North Pacific Ocean, and Southern Hemisphere. There are three stocks of blue whales designated in U.S. waters: the Eastern North Pacific Ocean (current best estimate N=1,647, N_{min}=1,551; (VanBlaricom et al. 1993)), Central North Pacific Ocean (N=81, N_{min}=38), and Western North Atlantic Ocean (N=400 to 600, N_{min}=440). In the Southern Hemisphere, the latest abundance estimate for Antarctic blue whales is 2,280 individuals in 1997/1998 (95 percent confidence intervals 1,160 to 4,500 (Branch 2007). While no rangewide estimate for pygmy blue whales exists (Thomas et al. 2016), the latest estimate for pygmy blue whales off the west coast of Australia is 662 to 1,559 individuals based on passive acoustic monitoring (McCauley and

Jenner 2010a), or 712 to 1,754 individuals based on photographic mark-recapture (Jenner et al. 2008).

Current estimates indicate a growth rate of just under three percent per year for the eastern North Pacific stock (Calambokidis et al. 2009). An overall population growth rate for the species or growth rates for the two other individual U.S. stocks are not available at this time. In the Southern Hemisphere, population growth estimates are available only for Antarctic blue whales, which estimate a population growth rate of 8.2 percent per year (95 percent confidence interval 1.6 to 14.8 percent) (Branch 2007).

Little genetic data exist on blue whales globally. Data from Australia indicates that at least populations in this region experienced a recent genetic bottleneck, likely the result of commercial whaling, although genetic diversity levels appear to be similar to other, non-threatened mammal species (Attard et al. 2010). Consistent with this, data from Antarctica also demonstrate this bottleneck but high haplotype diversity, which may be a consequence of the recent timing of the bottleneck and blue whales long lifespan (Sremba et al. 2012). Data on genetic diversity of blue whales in the Northern Hemisphere are currently unavailable. However, genetic diversity information for similar cetacean population sizes can be applied. Stocks that have a total population size of 2,000 to 2,500 individuals or greater provide for maintenance of genetic diversity resulting in long-term persistence and protection from substantial environmental variance and catastrophes. Stocks that have a total population of 500 individuals or less may be at a greater risk of extinction due to genetic risks resulting from inbreeding. Stock population at low densities (less than 100) are more likely to suffer from the ‘Allee’ effect, where inbreeding and the heightened difficulty of finding mates reduces the population growth rate in proportion with reducing density.

In general, distribution is driven largely by food requirements; blue whales are more likely to occur in waters with dense concentrations of their primary food source, krill. While they can be found in coastal waters, they are thought to prefer waters further offshore (Figure 5). In the North Atlantic Ocean, the blue whale range extends from the subtropics to the Greenland Sea. They are most frequently sighted in waters of eastern Canada with a majority of sightings taking place in the Gulf of St. Lawrence. In the North Pacific Ocean, blue whales range from Kamchatka to southern Japan in the west and from the Gulf of Alaska and California to Costa Rica in the east. They primarily occur off the Aleutian Islands and the Bering Sea. In the northern Indian Ocean, there is a “resident” population of blue whales with sightings being reported from the Gulf of Aden, Persian Gulf, Arabian Sea, and across the Bay of Bengal to Burma and the Strait of Malacca. In the Southern Hemisphere, distributions of subspecies can be segregated. The subspecies *B. m. intermedia* occurs in relatively high latitudes south of the “Antarctic Convergence” (located between 48 and 61° South latitude) and close to the ice edge. The subspecies *B. m. brevicauda* is typically distributed north of the Antarctic Convergence.

Vocalization and Hearing

Blue whales produce prolonged low-frequency vocalizations that include moans in the range from 12.5 to 400 Hz, with dominant frequencies from 16 to 25 Hz, and songs that span frequencies from 16 to 60 Hz that last up to 36 seconds repeated every one to two minutes (see Mcdonald et al. 1995). Berchok et al. (2006b) examined vocalizations of St. Lawrence blue whales and found mean peak frequencies ranging from 17 to 78.7 Hz. Reported SLs are 180 to 188 dB re: 1 µPa, but may reach 195 dB re: 1 µPa (Aburto et al. 1997; Ketten 1998; McDonald et al. 2001a; Clark and Gagnon 2004). Samaran et al. (2010) estimated Antarctic blue whale calls in the Indian Ocean at 179 ± 5 dB re: 1 µPa (rms) at 1 m in the 17 to 30 Hz range and pygmy blue whale calls at 175 ± 1 dB re: 1 µPa (rms) at 1 m in the 17 to 50 Hz range.

As with other baleen whale vocalizations, blue whale vocalization function is unknown, although numerous hypotheses exist (maintaining spacing between individuals, recognition, socialization, navigation, contextual information transmission, and location of prey resources) (Payne and Webb. 1971; Thompson et al. 1992; Edds-Walton 1997). Intense bouts of long, patterned sounds are common from fall through spring in low latitudes, but these also occur less frequently while in summer high-latitude feeding areas. Short, rapid sequences of 30 to 90 Hz calls are associated with socialization and may be displays by males based upon call seasonality and structure. The low frequency sounds produced by blue whales can, in theory, travel long distances, and it is possible that such long distance communication occurs (Payne and Webb. 1971; Edds-Walton 1997). The long-range sounds may also be used for echolocation in orientation or navigation (Tyack 1999).

Cetaceans have an auditory anatomy that follows the basic mammalian pattern, with some modifications to adapt to the demands of hearing in the sea. The typical mammalian ear is divided into the outer ear, middle ear, and inner ear. The outer ear is separated from the inner ear by the tympanic membrane, or eardrum. In terrestrial mammals, the outer ear, eardrum, and middle ear function to transmit airborne sound to the inner ear, where the sound is detected in a fluid. Since cetaceans already live in a fluid medium, they do not require this matching, and thus do not have an air-filled external ear canal. The inner ear is where sound energy is converted into neural signals that are transmitted to the central nervous system via the auditory nerve. Acoustic energy causes the basilar membrane in the cochlea to vibrate. Sensory cells at different positions along the basilar membrane are excited by different frequencies of sound (Tyack 1999). Baleen whales have inner ears that appear to be specialized for low frequency hearing. In a study of the morphology of the mysticete auditory apparatus, Ketten (1997a) hypothesized that large mysticetes have acute infrasonic hearing.

Blue whale vocalizations tend to be long (greater than 20 seconds), low frequency (less than 100 Hz) signals (Thomson and Richardson 1995b), with a range of 12 to 400 Hz and dominant energy in the infrasonic range of 12 to 25 Hz (Ketten 1998; McDonald et al. 2001b; Mellinger and Clark 2003). Vocalizations are predominantly songs and calls. Blue whale calls have high acoustic energy, with reports of 186 to 188 dB re: 1 µPa (rms) at 1m (Cummings and Thompson

1971b; McDonald et al. 2001b) and 195 dB re: 1 µPa (rms) at 1m (Aburto et al. 1997) SLs. Calls are short-duration sounds (two to five seconds) that are transient and frequency-modulated, having a higher frequency range and shorter duration than song units and often sweeping down in frequency (80 to 30 Hz), with seasonally variable occurrence.

Blue whale songs consist of repetitively patterned vocalizations produced over time spans of minutes to hours or even days (Cummings and Thompson 1971b; McDonald et al. 2001b). The songs are divided into pulsed/tonal units, which are continuous segments of sound, and phrases, repeated in combinations of one to five units (Payne and Mcvay 1971; Mellinger and Clark 2003). Songs can be detected for hundreds, and even thousands of kilometers (Stafford et al. 1998), and have only been attributed to males (McDonald et al. 2001b; Oleson et al. 2007a). Worldwide, songs are showing a downward shift in frequency (Mcdonald et al. 2009). For example, a comparison of recording from November 2003 and November 1964 and 1965 reveals a long-term shift in the frequency of blue whale calling near San Nicolas Island. In 2003, the spectral energy peak was 16 Hz compared to approximately 22.5 Hz in 1964 and 1965, illustrating a more than 30 percent shift in call frequency over four decades (McDonald et al. 2006b). McDonald et al. (2009) observed a 31 percent downward frequency shift in blue whale calls off the coast of California, and also noted lower frequencies in seven of the world's ten known blue whale songs originating in the Atlantic, Pacific, Southern, and Indian Oceans. Many possible explanations for the shifts exist but none have emerged as the probable cause.

Although general characteristics of blue whale calls are shared in distinct regions (Thompson et al. 1996; McDonald et al. 2001b; Mellinger and Clark 2003; Rankin et al. 2005), some variability appears to exist among different geographic areas (Rivers 1997). Sounds in the North Atlantic Ocean have been confirmed to have different characteristics (i.e., frequency, duration, and repetition) than those recorded in other parts of the world (Mellinger and Clark 2003; Berchok et al. 2006a). Clear differences in call structure suggestive of separate populations for the western and eastern regions of the North Pacific Ocean have also been reported (Stafford et al. 2001b); however, some overlap in calls from the geographically distinct regions have been observed, indicating that the whales may have the ability to mimic calls (Stafford and Moore 2005).

In Southern California, blue whales produce two predominant call types: Type B and D. B calls are stereotypic of blue whale population found in the eastern North Pacific (McDonald et al. 2006b) and are produced exclusively by males and associated with mating behavior (Oleson et al. 2007a). These calls have long durations (20 seconds) and low frequencies (10 to 100 Hz); they are produced either as repetitive sequences (song) or as singular calls. The B call has a set of harmonic tonals, and may be paired with a pulsed Type A call. Blue whale D calls are down-swept in frequency (100 to 40 Hz) with duration of several seconds. These calls are similar worldwide and are associated with feeding animals; they may be produced as call-counter-call between multiple animals (Oleson et al. 2007b). In the SOCAL Range Complex region, D call are produced in highest numbers during the late spring and early summer, and in diminished

numbers during the fall, when A-B song dominates blue whale calling (Oleson et al. 2007c; Hildebrand et al. 2011; Hildebrand et al. 2012).

Calling rates of blue whales tend to vary based on feeding behaviour. Stafford et al. (2005) recorded the highest calling rates when blue whale prey was closest to the surface during its vertical migration. Wiggins et al. (2005) reported the same trend of reduced vocalization during daytime foraging followed by an increase at dusk as prey moved up into the water column and dispersed. Blue whales make seasonal migrations to areas of high productivity to feed, and vocalize less at the feeding grounds then during migration (Burtenshaw et al. 2004). Oleson et al. (2007c) reported higher calling rates in shallow diving (less than 30 m [100 ft] whales, while deeper diving whales (greater than 50 m [165 ft]) were likely feeding and calling less.

Direct studies of blue whale hearing have not been conducted, but it assumed that blue whales can hear the same frequencies that they produce (low frequency) and are likely most sensitive to this frequency range (Richardson et al. 1995g; Ketten 1997b). Based on vocalizations and anatomy, blue whales are assumed to predominantly hear low-frequency sounds below 400 Hz (Croll et al. 2001b; Stafford and Moore 2005; Oleson et al. 2007c). In terms of functional hearing capability, blue whales belong to the low frequency group, which have a hearing range of 7 Hz to 22 kHz (Southall et al. 2007b).

Status

The blue whale is endangered as a result of past commercial whaling. In the North Atlantic Ocean, at least 11,000 blue whales were killed from the late nineteenth to mid-20th centuries. In the North Pacific, at least 9,500 whales were killed between 1910 and 1965. Commercial whaling no longer occurs, but blue whales are threatened by ship strikes, entanglement in fishing gear, pollution, harassment including due to whale watching, and reduced prey abundance and habitat degradation due to climate change. Because populations appear to be increasing in size, the species appears to be somewhat resilient to current threats; however, the species has not recovered to pre-exploitation levels.

Critical Habitat

No critical habitat has been designated for the blue whale.

Recovery Goals

See the 1998 *Final Recovery Plan for the Blue Whale* for complete downlisting/delisting criteria for each of the following recovery plan goals:

1. Determine stock structure of blue whale populations occurring in U.S. waters and elsewhere.
2. Estimate the size and monitor trends in abundance of blue whale populations.
3. Identify and protect habitat essential to the survival and recovery of blue whale populations.
4. Reduce or eliminate human-caused injury and mortality of blue whales.

5. Minimize detrimental effects of directed vessel interactions with blue whales.
6. Maximize efforts to acquire scientific information from dead stranded, and entangled blue whales.
7. Coordinate state, federal, and international efforts to implement recovery actions for blue whales.
8. Establish criteria for deciding whether to delist or downlist blue whales.

6.2 Fin Whale

The fin whale is a large, widely distributed baleen whale found in all major oceans and comprised of three subspecies: *B. p. physalus* in the Northern Hemisphere, and *B. p. quoyi* and *B. p. patachaonica* (a pygmy form) in the Southern Hemisphere (Figure 6).

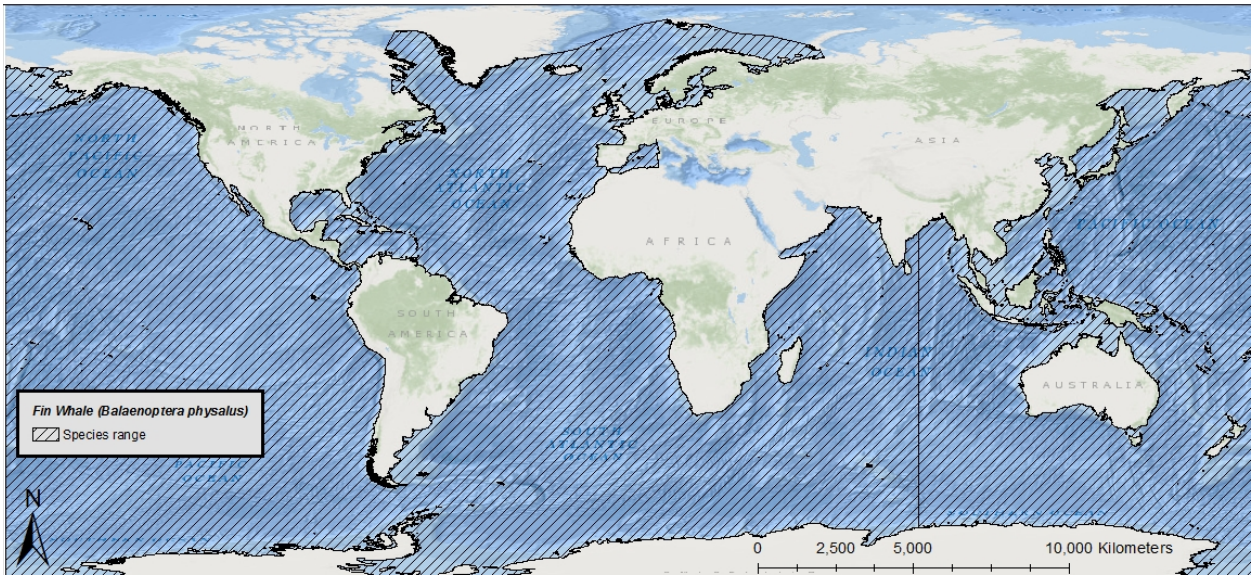

Figure 6. Map identifying the range of the endangered fin whale.

Fin whales are distinguishable from other whales by a sleek, streamlined body, with a V-shaped head, a tall falcate dorsal fin, and a distinctive color pattern of a black or dark brownish-gray body and sides with a white ventral surface. The lower jaw is gray or black on the left side and creamy white on the right side. The fin whale was originally listed as endangered on December 2, 1970 (Table 12).

Information available from the recovery plan (NMFS 2010c), recent stock assessment reports (Muto et al. 2017; Hayes et al. 2018; Carretta et al. 2019), and status review (NMFS 2011a) were used to summarize the life history, population dynamics and status of the species as follows.

Life History

Fin whales can live, on average, 80 to 90 years. They have a gestation period of less than one year, and calves nurse for six to seven months. Sexual maturity is reached between six and ten years of age with an average calving interval of two to three years. They mostly inhabit deep, offshore waters of all major oceans. They winter at low latitudes, where they calve and nurse,

and summer at high latitudes, where they feed, although some fin whales appear to be residential to certain areas. Fin whales eat pelagic crustaceans (mainly euphausiids or krill) and schooling fish such as capelin, herring, and sand lice.

Population Dynamics

The following is a discussion of the species' population and its variance over time. This section includes abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the fin whale.

The pre-exploitation estimate for the fin whale population in the North Pacific Ocean was 42,000 to 45,000 (Ohsumi and Wada 1974). In the North Atlantic Ocean, at least 55,000 fin whales were killed between 1910 and 1989. Approximately 704,000 fin whales were killed in the Southern Hemisphere from 1904 to 1975. Of the three to seven stocks in the North Atlantic Ocean (approximately 50,000 individuals), one occurs in U.S. waters, where the best estimate of abundance is 1,618 individuals (N_{min}=1,234); however, this may be an underrepresentation as the entire range of stock was not surveyed (Palka 2012). There are three stocks in U.S. Pacific Ocean waters: Northeast Pacific [minimum 1,368 individuals], Hawaii (approximately 58 individuals [N_{min}=27]) and California/Oregon/Washington (approximately 9,029 [N_{min}=8,127] individuals) (Nadeem et al. 2016) . The IWC also recognizes the China Sea stock of fin whales, found in the Northwest Pacific Ocean, which currently lacks an abundance estimate (Reilly et al. 2013). Abundance data for the Southern Hemisphere stock are limited; however, there were assumed to be somewhat more than 15,000 in 1983 (Thomas et al. 2016).

Current estimates indicate approximately 10,000 fin whales in U.S. Pacific Ocean waters, with an annual growth rate of 4.8 percent in the Northeast Pacific stock and a stable population abundance in the California/Oregon/Washington stock (Nadeem et al. 2016). Overall population growth rates and total abundance estimates for the Hawaii stock, China Sea stock, western North Atlantic stock, and Southern Hemisphere fin whales are not available at this time.

Archer et al. (2013) recently examined the genetic structure and diversity of fin whales globally. Full sequencing of the mitochondrial DNA genome for 154 fin whales sampled in the North Atlantic Ocean, North Pacific Ocean, and Southern Hemisphere, resulted in 136 haplotypes, none of which were shared among ocean basins suggesting differentiation at least at this geographic scale. However, North Atlantic fin whales appear to be more closely related to the Southern Hemisphere population, as compared to fin whales in the North Pacific Ocean, which may indicate a revision of the subspecies delineations is warranted. Generally speaking, haplotype diversity was found to be high both within oceans basins, and across. Such high genetic diversity and lack of differentiation within ocean basins may indicate that despite some population's having small abundance estimates, the species may persist long-term and be somewhat protected from substantial environmental variance and catastrophes.

There are over 100,000 fin whales worldwide, occurring primarily in the North Atlantic Ocean, North Pacific Ocean, and Southern Hemisphere where they appear to be reproductively isolated.

The availability of prey, sand lice in particular, is thought to have had a strong influence on the distribution and movements of fin whales.

Vocalization and Hearing

Fin whales produce a variety of low frequency sounds in the 10 to 200 Hz range (Watkins 1981b; Watkins et al. 1987; Edds 1988; Thompson et al. 1992). Typical vocalization are long, patterned pulses of short duration (0.5 to 2 seconds) in the 18 to 35 Hz range, but only males are known to produce these (Patterson and Hamilton 1964; Clark et al. 2002). Richardson et al. (1995g) reported the most common sound as a one second vocalization of about 20 Hz, occurring in short series during spring, summer, and fall, and in repeated stereotyped patterns in winter. Au (Au and Green 2000b) reported monas of 14 to 118 Hz, with a dominant frequency of 20 Hz, tonal vocalizations of 34 to 150 Hz, and songs of 17 to 25 Hz (Watkins 1981b; Edds 1988; Cummings and Thompson 1994). SLs for fin whale vocalizations are 140 to 200 dB re: 1 µPa (rms) at 1m (as compiled by Erbe 2002b; see also Clark and Gagnon 2004). The source depth of calling fin whales has been reported to be about 50 m (164 ft) (Watkins et al. 1987).

Although their function is still in doubt, low frequency fin whale vocalizations travel over long distances and may aid in long distance communication (Payne and Webb. 1971; Edds-Walton 1997). During the breeding season, fin whales produce pulses in a regular repeating pattern, which have been proposed to be mating displays similar to those of humpback whales (Croll et al. 2002). These vocal bouts last for a day or longer (Tyack 1999).

The inner ear is where sound energy is converted into neural signals that are transmitted to the central nervous system via the auditory nerve. Acoustic energy causes the basilar membrane in the cochlea to vibrate. Sensory cells at different positions along the basilar membrane are excited by different frequencies of sound (Tyack 1999). Baleen whales have inner ears that appear to be specialized for low frequency hearing. In a study of the morphology of the mysticete auditory apparatus, Ketten (1997a) hypothesized that large mysticetes have acute infrasonic hearing. In a study using computer tomography scans of a calf fin whale skull, Cranford and Krysl (2015) found sensitivity to a broad range of frequencies between ten and 12 kHz and a maximum sensitivity to sounds in the one to two kHz range.

Direct studies of fin whale hearing have not been conducted, but it is assumed that fin whales can hear the same frequencies that they produce (low) and are likely most sensitive to this frequency range (Richardson et al. 1995g; Ketten 1997b).

Fin whales produce a variety of low frequency (less than 1 kHz) sounds, but the most typically recorded is a 20 Hz pulse lasting about one second, and reaching SLs of 189 ±4 dB re: 1 µPa (rms) at 1m (Watkins 1981b; Watkins et al. 1987; Edds 1988; Richardson et al. 1995g; Charif et al. 2002; Clark et al. 2002; Sirovic et al. 2007). These pulses frequently occur in long sequenced patterns, are down swept (e.g., 23 to 18 Hz), and can be repeated over the course of many hours (Watkins et al. 1987). In temperate waters, intense bouts of these patterned sounds are very common from fall through spring, but also occur to a lesser extent during the summer in high

latitude feeding areas (Clarke and Charif 1998). The seasonality and stereotype nature of these vocal sequences suggest that they are male reproductive displays (Watkins 1981b; Watkins et al. 1987); a notion further supported by recent data linking these vocalizations to male fin whales only (Croll et al. 2002). In Southern California, the 20 Hz pulses are the dominant fin whale call type associated both with call-counter-call between multiple animals and with singing (U.S. Navy 2010; U.S. Navy 2012). An additional fin whale sound, the 40 Hz call described by Watkins (1981b), was also frequently recorded, although these calls are not as common as the 20 Hz fin whale pulses. Seasonality of the 40 Hz calls differed from the 20 Hz calls, since 40 Hz calls were more prominent in the spring, as observed at other sites across the northeast Pacific Ocean (Sirovic et al. 2012). SLs of Eastern Pacific Ocean fin whale 20 Hz calls has been reported as 189 ± 5.8 dB re: 1 µPa (rms) at 1 m (Weirathmueller et al. 2013). Although acoustic recordings of fin whales from many diverse regions show close adherence to the typical 20 Hz bandwidth and sequencing when performing these vocalizations, there have been slight differences in the pulse patterns, indicative of some geographic variation (Watkins et al. 1987; Thompson et al. 1992).

Responses to conspecific sounds have been demonstrated in a number of mysticetes, and there is no reason to believe that fin whales do not communicate similarly (Edds-Walton 1997). The low frequency sounds produced by fin whales have the potential to travel over long distances, and it is possible that long distance communication occurs in fin whales (Payne and Webb. 1971; Edds-Walton 1997). Also, there is speculation that the sounds may function for long range echolocation of large-scale geographic targets such as seamounts, which might be used for orientation and navigation (Tyack 1999).

Although no studies have directly measured the sound sensitivity of fin whales, experts assume that fin whales are able to receive sound signals in roughly the same frequencies as the signals they produce. This suggests fin whales, like other baleen whales, are more likely to have their best hearing capacities at low frequencies, including frequencies lower than those of normal human hearing, rather than mid- to high-frequencies (Ketten 1997b). Several fin whales were tagged during the Southern California Behavioral Response Study (SOCAL BRS) 2010 and no obvious responses to a mid-frequency sound source were detected by the visual observers or in the initial tag analysis (Southall et al. 2011a). Results of studies on blue whales (Southall et al. 2011a; Goldbogen et al. 2013b), which have similar auditory physiology compared to fin whales, indicate that some individuals hear some sounds in the mid-frequency range and exhibit behavioral responses to sounds in this range depending on received level and context, In terms of functional hearing capability fin whales belong to the low-frequency group, which have a hearing range of 7 Hz to 22 kHz (Southall et al. 2007b).

Status

The fin whale is endangered as a result of past commercial whaling. Prior to commercial whaling, hundreds of thousands of fin whales existed. Fin whales may be killed under “aboriginal subsistence whaling” in Greenland, under Japan’s scientific whaling program, and

Iceland's formal objection to the International Whaling Commission's ban on commercial whaling. Additional threats include ship strikes, reduced prey availability due to overfishing or climate change, and noise. The species' overall large population size may provide some resilience to current threats, but trends are largely unknown.

Critical Habitat

No critical habitat has been designated for the fin whale.

Recovery Goals

See the 2010 Final Recovery Plan for the fin whale for complete downlisting/delisting criteria for both of the following recovery goals:

1. Achieve sufficient and viable population in all ocean basins.
2. Ensure significant threats are addressed.

6.3 Gray Whale – Western North Pacific Population

The gray whale is a baleen whale and the only species in the family Eschrichtiidae. There are two isolated geographic distributions of gray whales in the North Pacific Ocean: the Eastern North Pacific stock, found along the west coast of North America, and the Western North Pacific or "Korean" stock, found along the coast of eastern Asia (Figure 7).

Gray whales are distinguishable from other whales by a mottled gray body, small eyes located near the corners of their mouth, no dorsal fin, broad, paddle-shaped pectoral fins and a dorsal hump with a series of eight to fourteen small bumps known as "knuckles". The gray whale was originally listed as endangered on December 2, 1970. The Eastern North Pacific stock was officially delisted on June 16, 1994 when it reached pre-exploitation numbers. The Western North Pacific population of gray whales remained listed as endangered (Table 12).

Information available from the recent stock assessment reports (Carretta et al. 2016; Muto et al. 2016; Waring et al. 2016b) were used to summarize the life history, population dynamics and status of the species as follows.

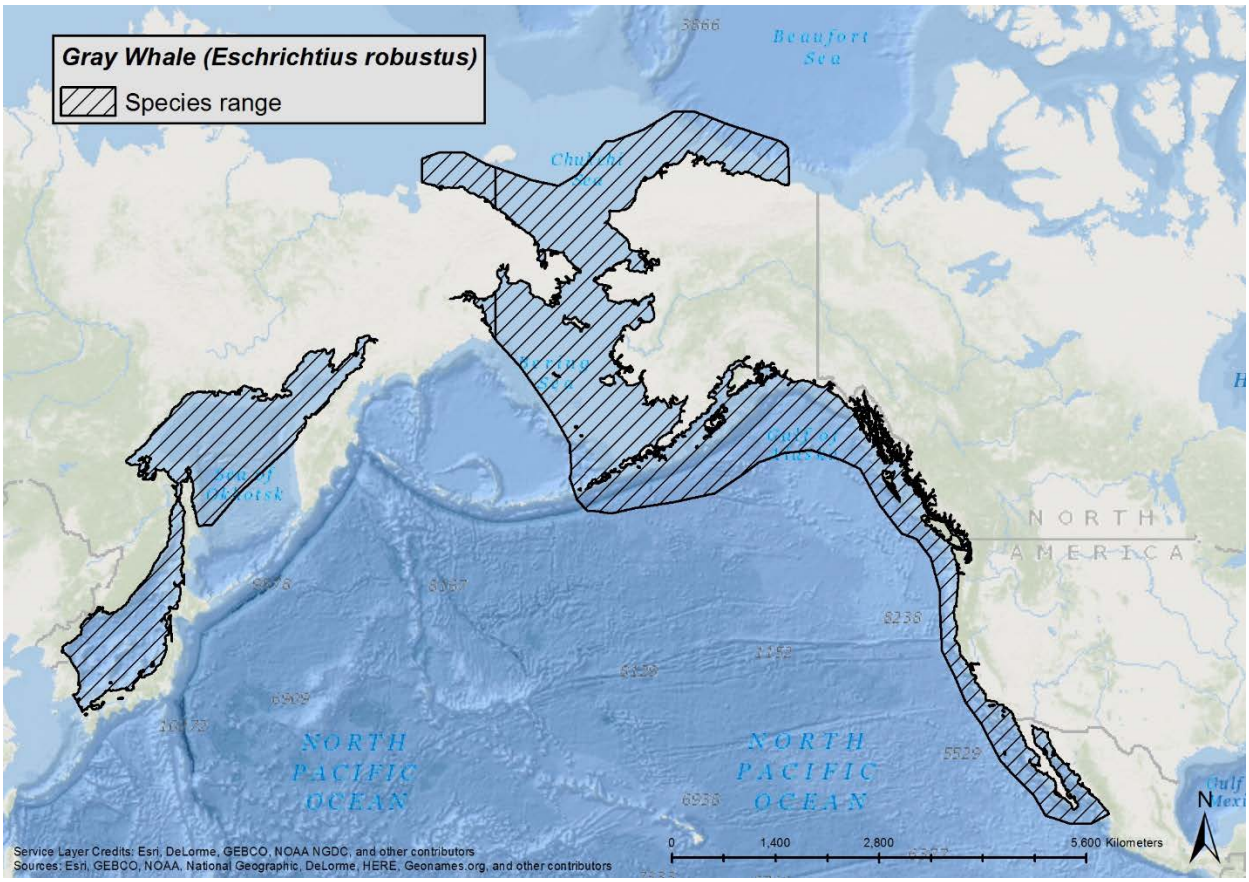

Figure 7. Map identifying the range of the endangered North Pacific gray whale.

Life History

The average life span of gray whales is unknown but it is thought to be as long as 80 years. They have a gestation period of twelve to thirteen months, and calves nurse for seven to eight months. Sexual maturity is reached between six and 12 years of age with an average calving interval of two to four years (Weller et al. 2009). Gray whales mostly inhabit shallow coastal waters in the North Pacific Ocean. Some Western North Pacific gray whales winter on the west coast of North America while others migrate south to winter in waters off Japan and China, and summer in the Okhotsk Sea off northeast Sakhalin Island, Russia, and off southeastern Kamchatka in the Bering Sea (Burdin et al. 2013). Gray whales travel alone or in small, unstable groups and are known as bottom feeders that eat “benthic” amphipods.

Population Dynamics

The following is a discussion of the species’ population and its variance over time. This section includes abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the gray whale.

Photo-identification data collected between 1994 and 2011 on the Western North Pacific gray whale summer feeding ground off Sakhalin Island were used to calculate an abundance estimate

of 175 whales for the non-calf population size in 2012 (Carretta et al. 2019). The minimum population estimate for the Western North Pacific stock is 135 individual gray whales on the summer feeding ground off Sakhalin Island. The current best growth rate estimate for the Western North Pacific gray whale stock is 3.3 percent annually.

There are often observed movements between individuals from the Eastern North Pacific stock and Western North Pacific stock; however, genetic comparisons show significant mitochondrial and nuclear genetic differences between whales sampled from each stock indicating genetically distinct populations (Leduc et al. 2002). A study conducted between 1995 and 1999 using biopsy samples found that Western North Pacific gray whales have retained a relatively high number of mitochondrial DNA haplotypes for such a small population. Although the number of haplotypes currently found in the Western North Pacific stock is higher than might be expected, this pattern may not persist into the future. Populations reduced to small sizes, such as the Western North Pacific stock, can suffer from a loss of genetic diversity, which in turn may compromise their ability to respond to changing environmental conditions (Willi et al. 2006) and negatively influence long-term viability (Spielman et al. 2004; Frankham 2005).

Gray whales in the Western North Pacific population are thought to feed in the summer and fall in the Okhotsk Sea, primarily off Sakhalin Island, Russia and the Kamchatka peninsula in the Bering Sea, and winter in the South China Sea. However, tagging, photo-identification, and genetic studies have shown that some whales identified as members of the Western North Pacific stock have been observed in the Eastern North Pacific Ocean, which may indicate that not all gray whales share the same migratory patterns.

Vocalization and Hearing

No data are available regarding Western North Pacific population gray whale hearing or communication. We assume that Eastern North Pacific population gray whale communication is representative of the Western North Pacific population and present information stemming from this population. Individuals produce broadband sounds within the 100 Hz to 12 kHz range (Thompson et al. 1979; Dahlheim et al. 1984; Jones and Swartz 2002). The most common sounds encountered are on feeding and breeding grounds, where “knocks” of roughly 142 dB re: 1 µPa (rms) at 1 m have been recorded (Cummings et al. 1968; Thomson and Richardson 1995b; Jones and Swartz 2002). However, other sounds have also been recorded in Russian foraging areas, including rattles, clicks, chirps, squeaks, snorts, thumps, knocks, bellows, and sharp blasts at frequencies of 400 Hz to 5 kHz (Petrochenko et al. 1991). Estimated SLs for these sounds ranged from 167 to 188 dB re: 1 µPa at 1 m (Petrochenko et al. 1991). Low frequency (less than 1.5 kHz) “bangs” and “moans” are most often recorded during migration and during ice-entrapment (Carroll et al. 1989; Crane and Lashkari. 1996). Sounds vary by social context and may be associated with startle responses (Rohrkasse-Charles et al. 2011). Calves exhibit the greatest variation in frequency range used, while adults are narrowest; groups with calves were never silent while in calving grounds (Rohrkasse-Charles et al. 2011). Based upon a single

captive calf, moans were more frequent when the calf was less than a year old, but after a year, croaks were the predominant call type (Wisdom et al. 1999).

Auditory structure suggests hearing is attuned to low frequencies (Ketten 1992b; Ketten 1992a). Responses of free-ranging and captive individuals to playbacks in the 160 Hz to 2 kHz range demonstrate the ability of individuals to hear within this range (Cummings and Thompson 1971a; Dahlheim and Ljungblad 1990; Buck and Tyack 2000; Wisdom et al. 2001; Moore and Clark 2002). Responses to low-frequency sounds stemming from oil and gas activities also support low-frequency hearing (Malme et al. 1986; Moore and Clark 2002).

Status

The Western North Pacific population of gray whale is endangered as a result of past commercial whaling and may still be hunted under "aboriginal subsistence whaling" provisions of the International Whaling Commission. Current threats include ship strikes, fisheries interactions (including entanglement), habitat degradation, harassment from whale watching, illegal whaling or resumed legal whaling, and noise.

Critical Habitat

No critical habitat has been designated for the Western North Pacific population of gray whale. NMFS cannot designate critical habitat in foreign waters.

Recovery Goals

There is currently no Recovery Plan for the Western North Pacific population of gray whale. In general, ESA-listed species, which occur entirely outside U.S. jurisdiction, are not likely to benefit from recovery plans (55 FR 24296; June 15, 1990).

6.4 North Pacific Right Whale

North Pacific right whales are found in temperate and sub-polar waters of the North Pacific Ocean (Figure 8).

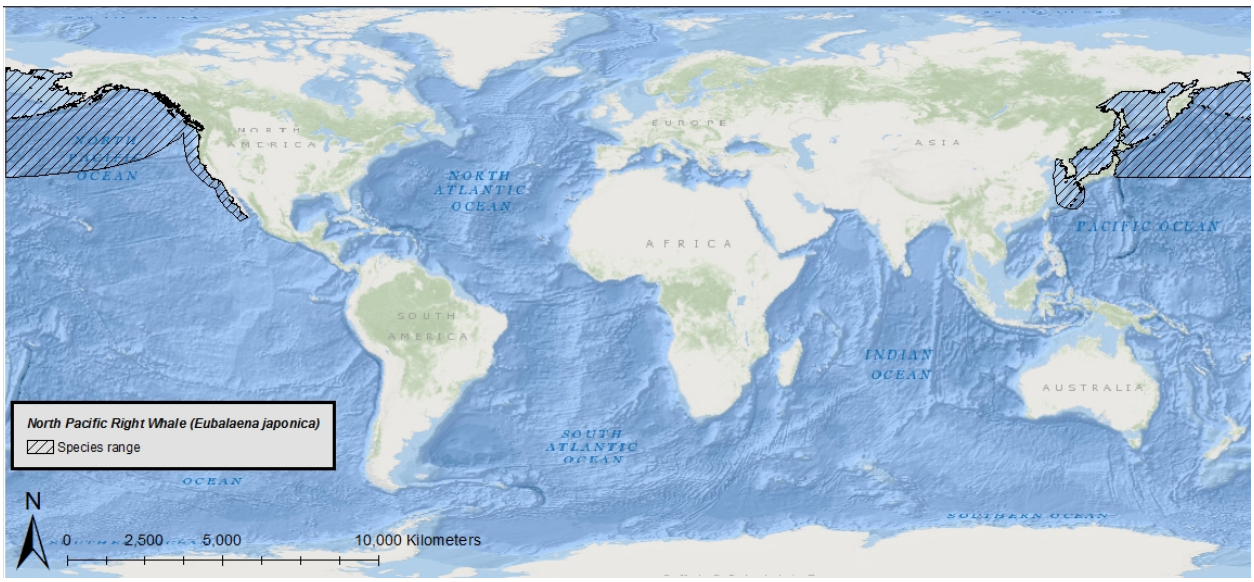

Figure 8. Map identifying the range of the endangered North Pacific right whale.

The North Pacific right whale is a baleen whale found only in the North Pacific Ocean and is distinguishable by a stocky body, lack of dorsal fin, generally black coloration, and callosities on the head region. The species was originally listed with the North Atlantic right whale (i.e., "Northern" right whale) as endangered on December 2, 1970. The North Pacific right whale was listed separately as endangered on March 6, 2008 (Table 12).

Information available from the recovery plan (NMFS 2013a) recent stock assessment reports (Muto et al. 2017), and status review (NMFS 2012a) were used to summarize the life history, population dynamics and status of the species as follows.

Life History

North Pacific right whales can live, on average, 50 or more years. They have a gestation period of approximately one year, and calves nurse for approximately one year. Sexual maturity is reached between nine and ten years of age. The reproduction rate of North Pacific right whales remains unknown. However, it is likely low due to a male-biased sex ratio that may make it difficult for females to find viable mates. North Pacific right whales mostly inhabit coastal and continental shelf waters. Little is known about their migration patterns, but they have been observed in lower latitudes during winter (Japan, California, and Mexico) where they likely calve and nurse. In the summer, they feed on large concentrations of copepods in Alaskan waters. North Pacific right whales are unique compared to other baleen whales in that they are skim feeders meaning they continuously filtering through their baleen while moving through a patch of zooplankton.

Population Dynamics

The following is a discussion of the species' population and its variance over time. This section includes abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the North Pacific right whale.

The North Pacific right whale remains one of the most endangered whale species in the world. Their abundance likely numbers fewer than 1,000 individuals. There are two currently recognized stocks of North Pacific right whales, a Western North Pacific stock that feeds primarily in the Sea of Okhotsk, and an Eastern North Pacific stock that feeds in eastern north Pacific Ocean waters off Alaska, Canada, and Russia. Several lines of evidence indicate a total population size of less than 100 for the Eastern North Pacific stock. Based on photo-identification from 1998 to 2013 (Wade et al. 2011) estimated 31 individuals, with a minimum population estimate of 26 individuals (Muto et al. 2017). Genetic data have identified 23 individuals based on samples collected between 1997 and 2011 (Leduc et al. 2012). The Western North Pacific stock is likely more abundant and was estimated to consist of 922 whales (95 percent confidence intervals 404 to 2,108) based on data collected in 1989, 1990, and 1992, however biases were detected with the survey methodology (IWC 2001; Thomas et al. 2016). While there have been several sightings of Western North Pacific right whales in recent years, with one sighting identifying at least 77 individuals, these data have yet to be compiled to provide a more recent abundance estimate (Thomas et al. 2016). There is currently no information on the population trend of North Pacific right whales.

As a result of past commercial whaling, the remnant population of North Pacific right whales has been left vulnerable to genetic drift and inbreeding due to low genetic variability. This low diversity potentially affects individuals by depressing fitness, lowering resistance to disease and parasites, and diminishing the whales' ability to adapt to environmental changes. At the population level, low genetic diversity can lead to slower growth rates, lower resilience, and poorer long-term fitness (Lacy 1997). Marine mammals with an effective population size of a few dozen individuals likely can resist most of the deleterious consequences of inbreeding (Lande 1991). It has also been suggested that if the number of reproductive animals is fewer than fifty, the potential for impacts associated with inbreeding increases substantially. Rosenbaum et al. (2000) found that historic genetic diversity of North Pacific right whales was relatively high compared to North Atlantic right whales, but samples from extant individuals showed very low genetic diversity, with only two matrilineal haplotypes among the five samples in their dataset.

The North Pacific right whale inhabits the Pacific Ocean, particularly between 20 and 60° North latitude (Figure 8). Prior to exploitation by commercial whalers, concentrations of North Pacific right whales where found in the Gulf of Alaska, Aleutian Islands, south central Bering Sea, Sea of Okhotsk, and Sea of Japan. There has been little recent sighting data of North Pacific right whales occurring in the central North Pacific and Bering Sea. However, since 1996, North Pacific right whales have been consistently observed in Bristol Bay and the southeastern Bering Sea during summer months. In the Western North Pacific Ocean where the population is thought

to be somewhat larger, North Pacific right whales have been sighted in the Sea of Okhotsk and other areas off the coast of Japan, Russia, and South Korea (Thomas et al. 2016). Although North Pacific right whales are typical found in higher latitudes, they are thought to migrate to more temperate waters during winter to reproduce, and have been sighted as far south as Hawaii and Baja California.

Vocalization and Hearing

Given their extremely small population size and remote location, little is known about North Pacific right whale vocalizations (Marques et al. 2011). However, data from other right whales is informative. Right whales vocalize to communicate over long distances and for social interaction, including communication apparently informing others of prey path presence (Biedron et al. 2005; Tyson and Nowacek 2005). Vocalization patterns amongst all right whale species are generally similar, with six major call types: scream, gunshot, blow, up call, warble, and down call (McDonald and Moore 2002b; Parks and Tyack 2005). A large majority of vocalizations occur in the 300 to 600 Hz range with up and down sweeping modulations (Vanderlaan et al. 2003). Vocalizations below 200 Hz and above 900 Hz were rare (Vanderlaan et al. 2003). Calls tend to be clustered, with periods of silence between clusters (Vanderlaan et al. 2003). Gunshot bouts last 1.5 hours on average and up to seven hours (Parks et al. 2012a). Blows are associated with ventilation and are generally inaudible underwater (Parks and Clark 2007). Up calls are 100 to 400 Hz (Gillespie and Leaper 2001). Gunshots appear to be largely or exclusively male vocalization (Parks et al. 2005b).

Smaller groups vocalize more than larger groups and vocalization is more frequent at night (Matthews et al. 2001). Moans are usually produced within 10 m (33 ft) of the surface (Matthews et al. 2001). Up calls were detected year-round in Massachusetts Bay except July and August and peaking in April (Mussoline et al. 2012). Individuals remaining in the Gulf of Maine through winter continue to call, showing a strong diel pattern of up call and gunshot vocalizations from November through January possibly associated with mating (Bort et al. 2011; Morano et al. 2012; Mussoline et al. 2012). Estimated SLs of gunshots in non-surface active groups are 201 dB re: 1 µPa peak-to-peak (Hotchkin et al. 2011). While in surface active groups, females produce scream calls and males produce up calls and gunshot calls as threats to other males; calves (at least female calves) produce warble sounds similar top their mothers' screams (Parks et al. 2003; Parks and Tyack 2005). SLs for these calls in surface active groups range from 137 to 162 dB re: 1 µPa-m (rms), except for gunshots, which are 174 to 192 dB re: 1 µPa-m (rms) (Parks and Tyack 2005). Up calls may also be used to reunite mothers with calves (Parks and Clark 2007). Atlantic right whales shift calling frequencies, particularly of up calls, as well as increase call amplitude over both long and short term periods due to exposure to vessel noise (Parks et al. 2005a; Parks et al. 2006; Parks and Clark 2007; Parks et al. 2007b; Parks et al. 2010; Parks et al. 2011b; Parks et al. 2012b), particularly the peak frequency (Parks et al. 2009b). North Atlantic right whales respond to anthropogenic sound designed to alert whales to vessel presence by surfacing (Nowacek et al. 2003; Nowacek et al. 2004c).

There is no direct data on the hearing range of North Pacific right whales. However, based on anatomical modeling, the hearing range for North Atlantic right whales is predicted to be from 10 Hz to 22 kHz with functional ranges probably between 15 Hz to 18 kHz (Parks et al. 2007c).

Status

The North Pacific right whale is endangered as a result of past commercial whaling. Prior to commercial whaling, abundance has been estimated to have been more than 11,000 individuals. Current threats to the survival of this species include hunting, ship strikes, climate change, and fisheries interactions (including entanglement). The resilience of North Pacific right whales to future perturbations is low due to its small population size and continued threats. Recovery is not anticipated in the foreseeable future (several decades to a century or more) due to small population size and lack of available current information.

Critical Habitat

In 2008, NMFS designated critical habitat for the North Pacific right whale, which includes an area in the Southeast Bering Sea and an area south of Kodiak Island in the Gulf of Alaska (Figure 9). These areas are influenced by large eddies, submarine canyons, or frontal zones which enhance nutrient exchange and act to concentrate prey. These areas are adjacent to major ocean currents and are characterized by relatively low circulation and water movement. Both critical habitat areas support feeding by North Pacific right whales because they contain the designated physical and biological features (previously referred to as primary constituent elements), which include: nutrients, physical oceanographic processes, certain species of zooplankton, and a long photoperiod due to the high latitude. Consistent North Pacific right whale sightings are a proxy for locating these elements.

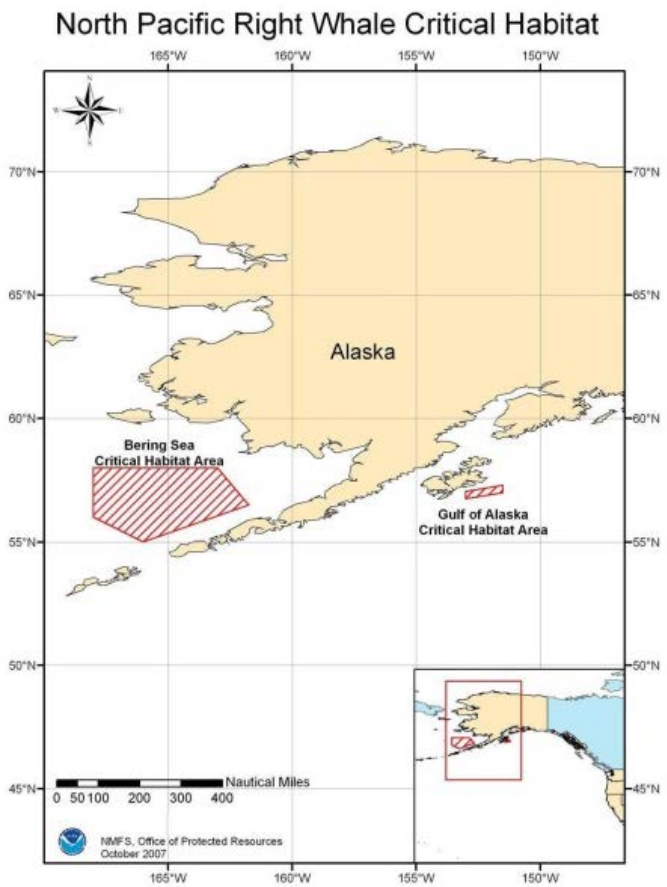

Figure 9. Map identifying designated critical habitat for the North Pacific right whale in the Southeast Bering Sea and south of Kodiak Island in the Gulf of Alaska.

Recovery Goals

See the 2013 Final Recovery Plan for the North Pacific right whale for complete downlisting/delisting criteria for both of the following recovery goals (78 FR 34347; June 7, 2013):

1. Achieve sufficient and viable populations in all ocean basins.
2. Ensure significant threats are addressed.

6.5 Sei Whale

The sei whale is a widely distributed baleen whale found in all major oceans (Figure 10). Sei whales are distinguishable from other whales by a long, sleek body that is dark bluish-gray to black in color and pale underneath, and a single ridge located on their rostrum. The sei whale was originally listed as endangered on December 2, 1970 (Table 12).

Information available from the recovery plan (NMFS 2011c), recent stock assessment reports (Muto et al. 2017; Hayes et al. 2018; Carretta et al. 2019), and status review (NMFS 2012c) were used to summarize the life history, population dynamics and status of the species as follows.

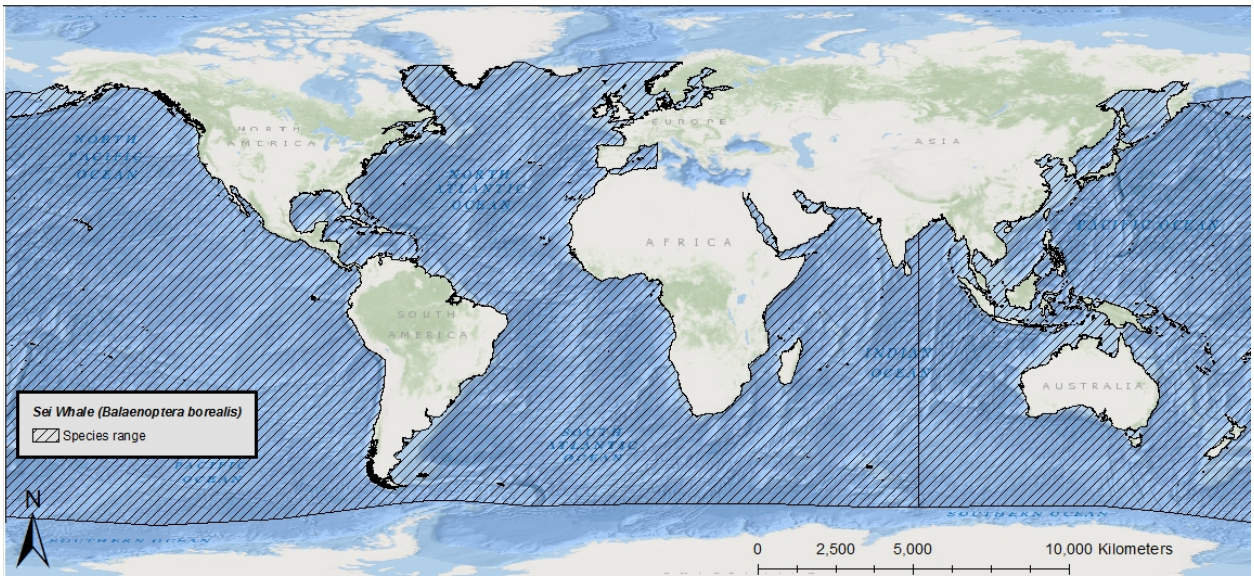

Figure 10. Map identifying the range of the endangered sei whale.

Life History

Sei whales can live, on average, between 50 and 70 years. They have a gestation period of ten to 12 months, and calves nurse for six to nine months. Sexual maturity is reached between six and 12 years of age with an average calving interval of two to three years. Sei whales mostly inhabit continental shelf and slope waters far from the coastline. They winter at low latitudes, where they calve and nurse, and summer at high latitudes, where they feed on a range of prey types, including: plankton (copepods and krill) small schooling fishes, and cephalopods.

Population Dynamics

The following is a discussion of the species' population and its variance over time. This section includes abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the sei whale.

Two sub-species of sei whale are recognized, *B. b. borealis* in the Northern Hemisphere and *B. b. schlegellii* in the Southern Hemisphere. There are no estimates of pre-exploitation abundance for the North Atlantic Ocean. Models indicate that total abundance declined from 42,000 to 8,600 individuals between 1963 and 1974 in the North Pacific Ocean. More recently, the North Pacific Ocean population was estimated to be 29,632 (95 percent confidence intervals 18,576 to 47,267) between 2010 and 2012 (IWC 2016a; Thomas et al. 2016). In the Southern Hemisphere, pre-exploitation abundance is estimated at 65,000 whales, with recent abundance estimated at 9,800 to 12,000 whales. Three relatively small stocks occur in U.S. waters: Nova Scotia (N=357,

N_{min}=236), Hawaii (N=178, N_{min}=93), and Eastern North Pacific (N=519, N_{min}=374). Population growth rates for sei whales are not available at this time as there are little to no systematic survey efforts to study sei whales.

While some genetic data exist sei whales, current samples sizes are small limiting our confidence in their estimates of genetic diversity (NMFS 2011c). However, genetic diversity information for similar cetacean population sizes can be applied. Stocks that have a total population size of 2,000 to 2,500 individuals or greater provide for maintenance of genetic diversity resulting in long-term persistence and protection from substantial environmental variance and catastrophes. Stocks that have a total population 500 individuals or less may be at a greater risk of extinction due to genetic risks resulting from inbreeding. Stock populations at low densities (less than100) are more likely to suffer from the 'Allee' effect, where inbreeding and the heightened difficulty of finding mates reduces the population growth rate in proportion with reducing density. All stocks of sei whales within U.S. waters are estimated to be below 500 individuals indicating they may be at risk of extinction due to inbreeding.

Sei whales are distributed worldwide, occurring in the North Atlantic Ocean, North Pacific Ocean, and Southern Hemisphere.

Vocalization and Hearing

Data on sei whale vocal behavior is limited, but includes records off the Antarctic Peninsula of broadband sounds in the 100 to 600 Hz range with 1.5 second duration and tonal and upsweep calls in the 200 to 600 Hz range of one to three second durations (McDonald et al. 2005). Vocalizations from the North Atlantic consisted of paired sequences (0.5 to 0.8 seconds, separated by 0.4 to 1.0 seconds) of 10 to 20 short (4 milliseconds) frequency modulated sweeps between 1.5 to 3.5 kHz (Thomson and Richardson 1995a). SLs of 189 ±5.8 dB re: 1µPa (rms) at 1 m have been established for sei whales in the northeastern Pacific Ocean (Weirathmueller et al. 2013). It is presumed sei whales hear in the same frequencies bands in which they vocalize, and are likely most sensitive to sounds in this frequency range.

Status

The sei whale is endangered as a result of past commercial whaling. Now, only a few individuals are taken each year by Japan; however, Iceland has expressed an interest in targeting sei whales. Current threats include ship strikes, fisheries interactions (including entanglement), climate change (habitat loss and reduced prey availability), and anthropogenic sound. Given the species' overall abundance, they may be somewhat resilience to current threats. However, trends are largely unknown, especially for individual stocks, many of which have relatively low abundance estimates.

Critical Habitat

No critical habitat has been designated for the sei whale.

Recovery Goals

See the 2011 Final Recovery Plan for the sei whale for complete downlisting/delisting criteria for both of the following recovery goals:

1. Achieve sufficient and viable populations in all ocean basins.
2. Ensure significant threats are addressed.

6.6 Humpback Whale – Western North Pacific Distinct Population Segment

The humpback whale is a widely distributed baleen whale found in all major oceans (Figure 11).

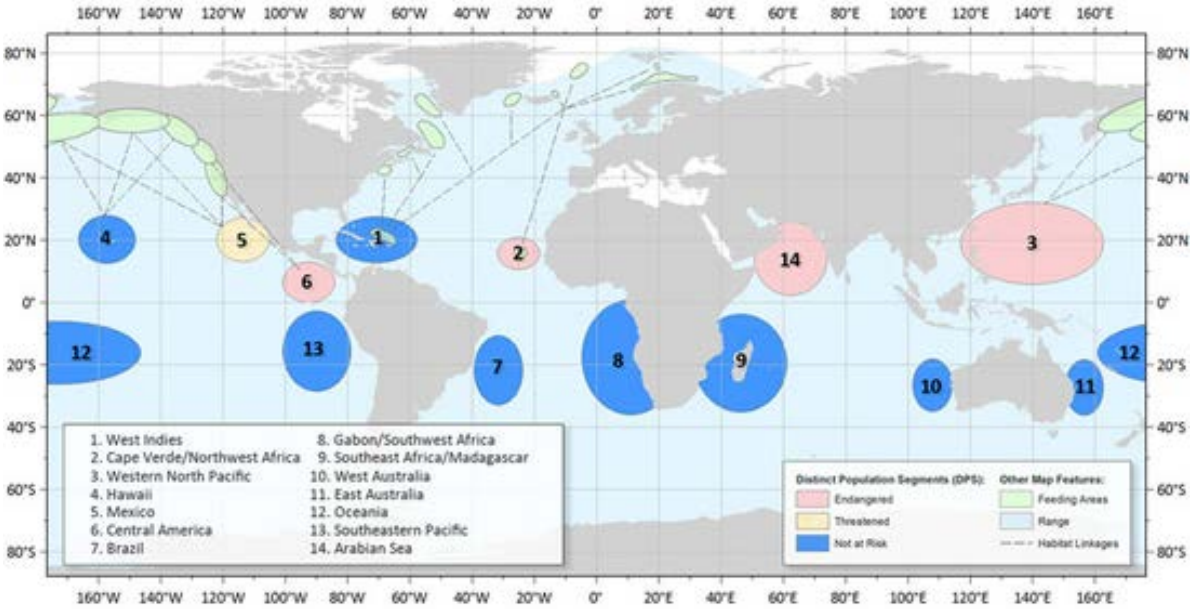

Figure 11. Map identifying 14 distinct population segments with one threatened and four endangered, based on primarily breeding location of the humpback whale, their range, and feeding areas (Bettridge et al. 2015).

Humpbacks are distinguishable from other whales by long pectoral fins and are typically dark grey with some areas of white. They humpback whale was originally listed as endangered on December 2, 1970. Since then, NMFS has designated 14 DPSs with four identified as endangered (Cape Verde Islands/Northwest Africa, Western North Pacific, Central America, and Arabian Sea) and one as threatened (Mexico) (Table 12).

Information available from the recovery plan (NMFS 1991a), recent stock assessment reports (Carretta et al. 2016; Muto et al. 2016; Waring et al. 2016a), the status review (Bettridge et al. 2015), and the final ESA-listing were used to summarize the life history, population dynamics and status of the species as follows.

Life History

Humpback whales can live, on average, 50 years. They have a gestation period of eleven to 12 months, and calves nurse for one year. Sexual maturity is reached between five to eleven years of age with an average calving interval of two to three years. Humpbacks mostly inhabit coastal and continental shelf waters. They winter at lower latitudes, where they calve and nurse, and summer at high latitudes, where they feed. Humpback whales exhibit a wide range of foraging behaviors and feed on a range of prey types, including: small schooling fishes, euphausiids, and other large zooplankton (Bettridge et al. 2015).

Population Dynamics

The following is a discussion of the species' population and its variance over time. This section includes abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the Western North Pacific DPS of humpback whales.

The global, pre-exploitation estimate for humpback whales is 1,000,000 (Roman and Palumbi 2003). The current abundance of the Western North Pacific DPS is 1,059. A population growth rate is currently unavailable for the Western North Pacific DPS of humpback whales.

For humpback whales, DPSs that have a total population size of 2,000 to 2,500 individuals or greater provide for maintenance of genetic diversity resulting in long-term persistence and protection from substantial environmental variance and catastrophes. DPSs that have a total population of 500 individuals or less may be at a greater risk of extinction due to genetic risks resulting from inbreeding. Population at low densities (less than one hundred) are more likely to suffer from the 'Allee" effect, where inbreeding and the heightened difficulty of finding mates reduces the population growth rate in proportion with reducing density. The Western North Pacific DPS has less than 2,000 individuals total, and is made up of two sub-populations, Okinawa/Philippines and the Second West Pacific. Thus, while its genetic diversity may be protected from moderate environmental variance, it could be subject to extinction due to genetic risks due to low abundance (Bettridge et al. 2015).

The Western North Pacific DPS is composed of humpback whales that breed/winter in the area of Okinawa and the Philippines, another unidentified breeding area (inferred from sightings of whales in the Aleutian Islands area feeding grounds), and those transiting from the Ogasawara area. These whales migrate to feeding grounds in the northern Pacific, primarily off the Russian coast (Figure 11). The abundance of humpback whales in the Western North Pacific DPS is estimated to be around 1,000, based on the photo-identification, capture-recapture analyses from the years 2004-2006 by the SPLASH program (Bettridge et al. 2015).

Vocalization and Hearing

Humpback whale vocalization is much better understood than is hearing. Different sounds are produced that correspond to different functions: feeding, breeding, and other social calls (Dunlop et al. 2008). Males sing complex sounds while in low-latitude breeding areas in a frequency

range of 20 Hz to 4 kHz with estimated SLs from 144 to 174 dB re 1 µPa (rms) (Winn et al. 1970; Richardson et al. 1995g; Au et al. 2000b; Frazer and Mercado Iii 2000; Au et al. 2006b). Males also produce sounds associated with aggression, which are generally characterized by frequencies between 50 Hz to 10 kHz with most energy below 3 kHz (Tyack 1983; Silber 1986). Such sounds can be heard up to 9 km (4.9 nmi) away (Tyack 1983). Other social sounds from 50 Hz to 10 kHz (most energy below 3 kHz) are also produced in breeding areas (Tyack 1983; Richardson et al. 1995g). While in northern feeding areas, both sexes vocalize in grunts (25 Hz to 1.9 kHz), pulses (25 to 89 Hz) and songs (ranging from 30 Hz to 8 kHz but dominant frequencies of 120 Hz to 4 kHz), which can be very loud (175 to 192 dB re: 1 µPa at 1 m) (Payne 1985; Thompson et al. 1986; Richardson et al. 1995g; Au et al. 2000b; Erbe 2002a). However, humpback whales tend to be less vocal in northern feeding areas than in southern breeding areas (Richardson et al. 1995g). NMFS classified humpback whales in the low-frequency cetacean (i.e., baleen whale) functional hearing group. As a group, it is estimated that baleen whales can hear frequencies between 0.007 and 30 Hz (NOAA 2013). Houser et al. (2001a) produced a mathematical model of humpback whale hearing sensitivity based on the anatomy of the humpback whale ear. Based on the model, they concluded that humpback whales would be sensitive to sound in frequencies ranging from 0.7 to 10 kHz, with a maximum sensitivity between 2 to 6 kHz.

Humpback whales are known to produce three classes of vocalizations: (1) “songs” in the late fall, winter, and spring by solitary males; (2) social sounds made by calves (Zoidis et al. 2008) or within groups on the wintering (calving) grounds; and (3) social sounds made on the feeding grounds (Thomson and Richardson 1995b). The best-known types of sounds produced by humpback whales are songs, which are thought to be reproductive displays used on breeding grounds and sung only by adult males (Schevill et al. 1964; Helweg et al. 1992; Gabriele and Frankel. 2002; Clark and Clapham 2004; Smith et al. 2008). Singing is most common on breeding grounds during the winter and spring months, but is occasionally heard in other regions and seasons (Mcsweeney et al. 1989; Gabriele and Frankel. 2002; Clark and Clapham 2004). Au et al. (2000a) noted that humpback whales off Hawaii tended to sing louder at night compared to the day. There is a geographical variation in humpback whale song, with different populations singing a basic form of a song that is unique to their own group. However, the song evolves over the course of a breeding season but remains nearly unchanged from the end of one season to the start of the next (Payne et al. 1983). The song is an elaborate series of patterned vocalizations that are hierarchical in nature, with a series of songs (‘song sessions’) sometimes lasting for hours (Payne and Mcvay 1971). Components of the song range from below 20 Hz up to 4 kHz, with SLs measured between 151 and 189 dB re: 1 µPa (rms) at 1m and high frequency harmonics extending beyond 24 kHz (Winn et al. 1970; Au et al. 2006b).

Social calls range from 20 Hz to 10 kHz, with dominant frequencies below 3 kHz (D'Vincent et al. 1985; Silber 1986; Simao and Moreira 2005; Dunlop et al. 2008). Female vocalizations appear to be simple; Simao and Moreira (2005) noted little complexity.

"Feeding" calls, unlike song and social sounds are a highly stereotyped series of narrow-band trumpeting calls. These calls are 20 Hz to 2 kHz, less than one second in duration, and have SLs of 162 to 192 dB re: 1 µPa (rms) at 1m (D'Vincent et al. 1985; Thompson et al. 1986). The fundamental frequency of feeding calls is approximately 500 Hz (D'Vincent et al. 1985; Thompson et al. 1986). The acoustics and dive profiles associated with humpback whale feeding behavior in the northwest Atlantic Ocean has been documented with DTAGs (Stimpert et al. 2007). Underwater lunge behavior was associated with nocturnal feeding at depth and with multiple boats of broadband click trains that were acoustically different from toothed whale echolocation: Stimpert et al. (Stimpert et al. 2007) termed these sounds "mega-clicks" which showed relatively low received levels at the DTAGs (143 to 154 dB re: 1 µPa), with the majority of acoustic energy below 2 kHz.

In terms of functional hearing capability, humpback whales belong to low frequency cetaceans which have a hearing range of 7 Hz to 22 kHz (Southall et al. 2007b). Humpback whale audiograms using a mathematical model based on the internal structure of the ear estimate sensitivity is from 700 Hz to 10 kHz, with maximum relative sensitivity between 2 kHz and 6 kHz (Ketten and Mountain 2014). Research by Au et al. (2001) and Au et al. (2006a) off Hawaii indicated the presence of high frequency harmonics in vocalizations up to and beyond 24 kHz. While recognizing this was the upper limit of the recording equipment, it does not demonstrate that humpback whales can actually hear those harmonics, which may simply be correlated harmonics of the frequency fundamental in the humpback whale song. The ability of humpback whales to hear frequencies around 3 kHz may have been demonstrated in a playback study. Maybaum (1990) reported that humpback whales showed a mild response to a handheld sonar marine mammal detection and location device with frequency of 3.3 kHz at 219 dB re: 1 µPa-m or frequency sweep of 3.1 to 3.6 kHz. In addition, the system had some low frequency components (below 1 kHz) which may have been an artifact of the acoustic equipment. This possible artifact may have affected the response of the whales to both the control and sonar playback conditions.

Status

Humpback whales were originally listed as endangered as a result of past commercial whaling, and the five DPSs that remain listed (Cape Verde Islands/Northwest Africa, Western North Pacific, Central America, Arabian Sea, and Mexico) have likely not yet recovered from this. Prior to commercial whaling, hundreds of thousands of humpback whales existed. Global abundance declined to the low thousands by 1968, the last year of substantial catches (IUCN 2012). Humpback whales may be killed under "aboriginal subsistence whaling" and "scientific permit whaling" provisions of the International Whaling Commission. Additional threats include ship strikes, fisheries interactions (including entanglement), energy development, harassment from whaling watching noise, harmful algal blooms, disease, parasites, and climate change. The species' large population size and increasing trends indicate that it is resilient to current threats, but the Western North Pacific DPS of humpback whales still faces a risk of extinction.

Critical Habitat

No critical habitat has been designated for humpback whales.

Recovery Goals

See the 1991 Final Recovery Plan for the humpback whale for the complete downlisting/delisting criteria for each of the four following recovery goals:

1. Maintain and enhance habitats used by humpback whales currently or historically.
2. Identify and reduce direct human-related injury and mortality.
3. Measure and monitor key population parameters.
4. Improve administration and coordination of recovery program for humpback whales.

6.7 False Killer Whale – Main Hawaiian Islands Insular Distinct Population Segment

False killer whales are distributed worldwide in tropical and temperate waters more than 1,000 m deep. The Main Hawaiian Islands Insular DPS of false killer whales is found in waters around the Main Hawaiian Islands (Figure 12).

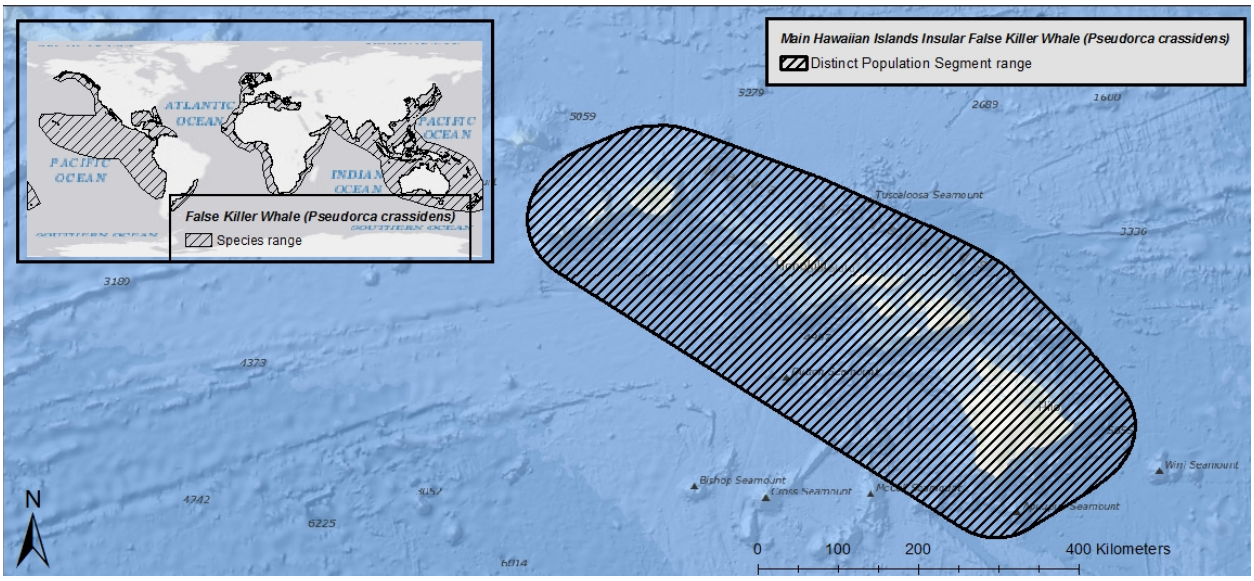

Figure 12. Map identifying the range of false killer whales and the Main Hawaiian Islands Insular distinct population segment of false killer whale.

The false killer whale is a toothed whale and large member of the dolphin family. False killer whales are distinguishable from other whales by having a small conical head without a beak, tall dorsal fin, and a distinctive bulge in the middle of the front edge of their pectoral fins. The Main Hawaiian Islands Insular DPS of false killer whale was listed as endangered on November 28, 2012 (77 FR 70915) (Table 12).

Information available from the most recent status review (NMFS 2010d) and recent stock assessment (Carretta et al. 2011) were used to summarize the status of the species as follows.

Life History

False killer whales can live, on average, for 60 years. They have a gestation period of 14 to 16 months, and calves nurse for 1.5 to two years. Sexual maturity is reached around 12 years of age with a very low reproduction rate and calving interval of approximately seven years. False killer whales prefer tropical to temperate waters that are deeper than 1,000 m. They feed during the day and at night on fishes and cephalopods, and are known to attack other marine mammals, indicating they may occasionally feed on them.

Population Dynamics

The following is a discussion of the species' population and its variance over time. This section includes abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the Main Hawaiian Islands Insular DPS of false killer whales.

Recent, unpublished estimates of abundance for two time periods, 2000 to 2004 and 2006 to 2009, were 162 and 151 respectively. The minimum population estimate for the Main Hawaiian Islands Insular DPS of false killer whale is the number of distinct individuals identified during the 2011 to 2014 photo-identification studies, or ninety-two false killer whales (Baird et al. 2015). The most recent stock assessment report estimates abundance at 167 (CV=0.14), and a minimum population size of 149 individuals (Carretta et al. 2019).

A current estimated population growth rate for the Main Hawaiian Islands Insular DPS of false killer whales is not available at this time (Carretta et al. 2019). Reeves et al. (2009) suggested that the population may have declined during the last two decades, based on sighting data collected near Hawaii using various methods between 1989 and 2007. A modeling exercise conducted by Oleson et al. (2010b) evaluated the probability of actual or near extinction, defined as fewer than 20 animals, given measured, estimated, or inferred information on population size and trends, and varying impacts of catastrophes, environmental stochasticity and Allee effects. A variety of alternative scenarios were evaluated indicating the probability of decline to fewer than 20 animals within 75 years as greater than 20 percent. Although causation was not evaluated, all models indicated current declines at an average rate of negative nine percent since 1989.

The Main Hawaiian Islands Insular DPS of false killer whale is considered resident to the Main Hawaiian Islands and is genetically and behaviorally distinct compared to other stocks. Genetic data suggest little immigration into the Main Hawaiian Islands Insular DPS of false killer whale (Baird et al. 2012). Genetic analyses indicated restricted gene flow between false killer whales sampled near the Main Hawaiian Islands, the Northwestern Hawaiian Islands, and pelagic waters of the Eastern and Central North Pacific.

NMFS currently recognizes three stocks of false killer whales in Hawaiian waters: the Main Hawaiian Islands Insular, Hawaii pelagic, and the Northwestern Hawaiian Islands. All false killer whales found within 40 km of the Main Hawaiian Islands belong to the insular stock and all false killer whales beyond 140 km belong to the pelagic stock. Animals belonging to the

Northwest Hawaiian Islands stock are insular to the Northwest Hawaiian Islands (Bradford et al. 2012), however, this stock was identified by animals encountered off Kauai.

Vocalization and Hearing

Functional hearing in mid-frequency cetaceans, including Main Hawaiian Islands Insular DPS of false killer whales, is conservatively estimated to be between approximately 150 Hz and 160 kHz (Southall et al. 2007b). There are three categories of sounds that odontocetes make. The first includes echolocation sounds of high intensity, high frequency, high repetition rate, and very short duration (Au et al. 2000b). The second category of odontocete sounds is comprised of pulsed sounds. Burst pulses are generally very complex and fast, with frequency components sometimes above 100 kHz and average repetition rates of 300 per second (Yuen et al. 2007).

The final category of odontocete sounds is the narrowband, low frequency, tonal whistles (Caldwell et al. 1990; Au et al. 2000b). With most of their energy below 20 kHz, whistles have been observed with an extensive variety of frequency patterns, durations, and SLs, each of which can be repeated or combined into more complex phrases (Tyack and Clark 2000; Yuen et al. 2007).

In general, odontocetes produce sounds across the wildest band of frequencies. Their social vocalizations range from a few hundreds of Hz to tens of kHz (Southall et al. 2007b) with SLs in the range of 100 to 170 dB re: 1 µPa (rms) (see (Richardson et al. 1995g)). They also generate specialized clocks used in echolocation at frequencies above 100 kHz that are used to detect, localize and characterize underwater objects such as prey (Au et al. 1993). Echolocation clicks have SLs that can be as high as 229 dB re: 1 µPa peak-to-peak (Au et al. 1974).

Nachtigall and Supin (2008) investigated the signals from an echolocating false killer whale and found that the majority of clicks had a single-lobed structure with peak energy between 20 and 80 kHz false rather than dual-lobed clicks, as has been demonstrated in the bottlenose dolphin. Navy researchers measured the hearing of a false killer whale and demonstrated the ability of this species to change its hearing during echolocation (Nachtigall and Supin. 2008). They found that there are at least three mechanisms of automatic gain control in odontocete echolocation, suggesting that echolocation and hearing are a very dynamic process (Nachtigall and Supin. 2008). For instance, false killer whales change the focus of the echolocation beam based on the difficulty of the task and the distance to the target. The echo from an outgoing signal can change by as much as 40 dB, but the departing and returning signal are the same strength entering the brain (Nachtigall and Supin. 2008). The Navy demonstrated that with a warning signal, the false killer whale can adjust hearing by 15 dB prior to sound exposure (Nachtigall and Supin. 2008).

Status

The exact causes for the decline in the Main Hawaiian Islands Insular DPS of the false killer whale are not specifically known, but multiple factors have threatened and continue to threaten the population. Threats to the DPS include small population size, including inbreeding depression and Allee effects, exposure to environmental contaminants, competition for food with

commercial fisheries, and hooking, entanglement, or intentional harm by fishermen. Recent photographic evidence of dorsal fin disfigurements and mouthline injuries suggest a high rate of fisheries interactions for this population compared to others in Hawaiian waters (Baird et al. 2015).

Critical Habitat

As stated in Section 5.6, critical habitat for the Main Hawaiian Islands Insular DPS of the false killer whale was designated on July 24, 2018, with an effective date of August 23, 2018 (83 FR 35062). The designation would include waters from the 45-meter depth contour to the 3,200-meter depth contour around the Main Hawaiian Islands. Parts of the designation are excluded for national security or economic reasons.

The designated critical habitat includes one physical and biological feature essential for conservation of the species, with the following four characteristics:

- Adequate space for movement and use within shelf slope and habitat.
- Prey species of sufficient quantity, quality, and availability to support individual growth, reproduction, and development, as well as overall population growth.
- Waters free of pollutants of a type and amount harmful to main Hawaiian Islands insular false killer whales.
- Sound levels that would not significantly impair false killer whales' use or occupancy.

Recovery Goals

There is currently no Recovery Plan available for the Main Hawaiian Islands Insular DPS of the false killer whale.

6.8 Sperm Whale

The sperm whale is a widely distributed species found in all major oceans (Figure 13).

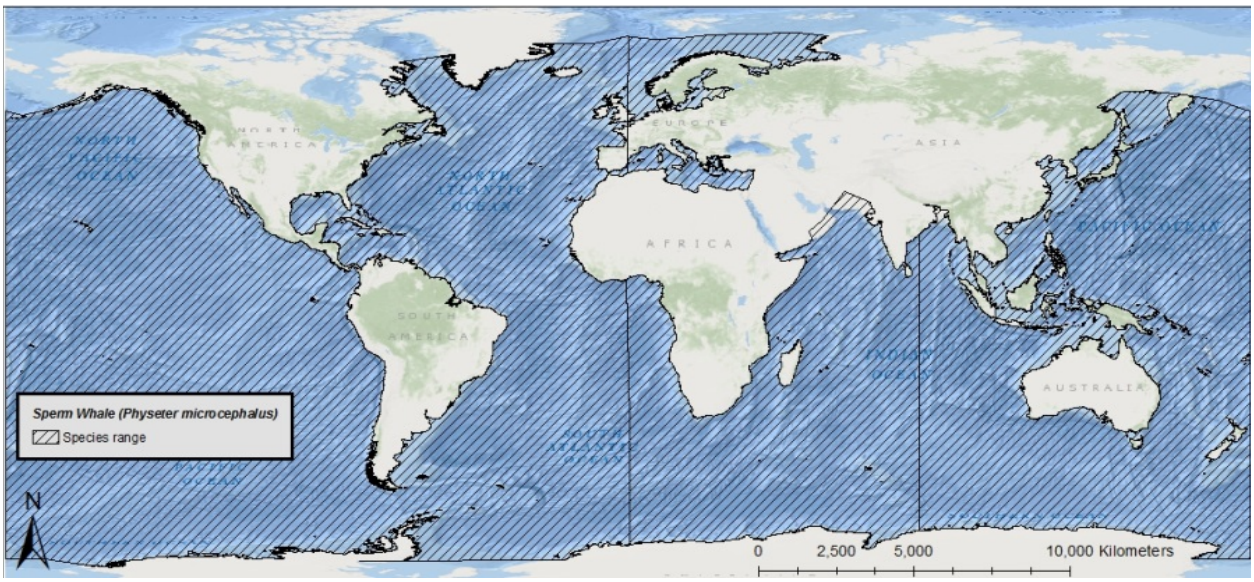

Figure 13. Map identifying the range of the endangered sperm whale.

Sperm whales are the largest toothed whale and distinguishable from other whales by its extremely large heard, which takes up to 25 to 35 percent of its total body length and a single blowhole asymmetrically situated on the left side of the head near the tip. The sperm whale was originally listed as endangered on December 2, 1970 (Table 12).

Information available from the recovery plan (NMFS 2010b), recent stock assessment reports (Muto et al. 2017; Hayes et al. 2018; Carretta et al. 2019), and status review (NMFS 2015f) were used to summarize the life history, population dynamics and status of the species as follows.

Life History

The average lifespan of sperm whales is estimated to be at least 50 years (Whitehead 2009). They have a gestation period of one to one and a half years, and calves nurse for approximately two years. Sexual maturity is reached between seven and 13 years of age for females with an average calving interval for four to six years. Male sperm whales reach full sexual maturity in their twenties. Sperm whales mostly inhabit areas with a water depth of 600 m (1,968 ft) or more, and are uncommon in waters less than 300 m (984 ft) deep. They winter at low latitudes, where they calve and nurse, and summer at high latitudes, where they feed primarily on squid; other prey includes octopus and demersal fish (including teleosts and elasmobranchs).

Population Dynamics

The following is a discussion of the species' population and its variance over time. This section includes abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the sperm whale.

The sperm whale is the most abundant of the large whale species, with total abundance estimates between 200,000 and 1,500,000. The most recent estimate indicated a global population of between 300,000 and 450,000 individuals (Whitehead 2009). The higher estimates may be

approaching population sizes prior to commercial whaling, the reason for ESA-listing. There are no reliable estimates for sperm whale abundance across the entire Atlantic Ocean. However, estimates are available for two to three U.S. stocks in the Atlantic Ocean, the Northern Gulf of Mexico stock, estimated to consists of 763 individuals (N_{min}=560) and the North Atlantic stock, underestimated to consist of 2,288 individuals (N_{min}=1,815). There are insufficient data to estimate abundance for the Puerto Rico and U.S. Virgin Islands stock. In the northeast Pacific Ocean, the abundance of sperm whales was estimated to be between 26,300 and 32,100 in 1997. In the eastern tropical Pacific Ocean, the abundance of sperm whales was estimated to be 22,700 (95 percent confidence intervals 14,800 to 34,600) in 1993. Population estimates are also available for two to three U.S. stocks that occur in the Pacific, the California/Oregon/Washington stock, estimated to consist of 2,106 individuals (N_{min}=1,332), and the Hawaii stock, estimated to consist of 3,354 individuals (N_{min}=2,539). There are insufficient data to estimate the population abundance of the North Pacific stock. We are aware of no reliable abundance estimates specifically for sperm whales in the South Pacific Ocean, and there is insufficient data to evaluate trends in abundance and growth rates of sperm whale populations at this time. There is insufficient data to evaluate trends in abundance and growth rates of sperm whales at this time.

Ocean-wide genetic studies indicate sperm whales have low genetic diversity, suggesting a recent bottleneck, but strong differentiation between matrilineally related groups (Lyrholm and Gyllensten 1998). Consistent with this, two studies of sperm whales in the Pacific Ocean indicate low genetic diversity (Mesnick et al. 2011; Rendell et al. 2012). Furthermore, sperm whales from the Gulf of Mexico, the western North Atlantic Ocean, the North Sea, and the Mediterranean Sea all have been shown to have low levels of genetic diversity (Engelhaupt et al. 2009). As none of the stocks for which data are available have high levels of genetic diversity, the species may be at some risk to inbreeding and 'Allee' effects, although the extent to which is currently unknown. Sperm whales have a global distribution and can be found in relatively deep waters in all ocean basins. While both males and females can be found in latitudes less than 40°, only adult males venture into the higher latitudes near the poles.

Vocalization and Hearing

Sound production and reception by sperm whales are better understood than in most cetaceans. Sperm whales produce broadband clicks in the frequency range of 100 Hz to 20 kHz that can be extremely loud for a biological source (200 to 236 dB re: 1 µPa), although lower SL energy has been suggested at around 171 dB re: 1 µPa (Weilgart and Whitehead 1993; Goold and Jones 1995; Weilgart and Whitehead 1997b; Møhl et al. 2003). Most of energy in sperm whale clicks is concentrated at around 2 to 4 kHz and 10 to 16 kHz (Weilgart and Whitehead 1993; Goold and Jones 1995; NMFS 2006d). The highly asymmetric head anatomy of sperm whales is likely an adaptation to produce the unique clicks recorded from these animals (Norris and Harvey 1972; Norris and Harvey. 1972; Cranford 1992). Long, repeated clicks are associated with feeding and echolocation (Weilgart and Whitehead 1993; Goold and Jones 1995; Weilgart and Whitehead 1997b). However, clicks are also used in short patterns (codas) during social behavior and

intragroup interactions (Weilgart and Whitehead 1993). They may also aid in intra-specific communication. Another class of sound, "squeals," are produced with frequencies of 100 Hz to 20 kHz (e.g., Weir et al. 2007).

Our understanding of sperm whale hearing stems largely from the sounds they produce. The only direct measurement of hearing was from a young stranded individual from which auditory evoked potentials were recorded (Carder and Ridgway 1990). From this whale, responses support a hearing range of 2.5 to 60 kHz. However, behavioral responses of adult, free-ranging individuals also provide insight into hearing range; sperm whales have been observed to frequently stop echolocating in the presence of underwater pulses made by echosounders and submarine sonar (Watkins and Schevill 1975a; Watkins et al. 1985a). They also stop vocalizing for brief periods when codas are being produced by other individuals, perhaps because they can hear better when not vocalizing themselves (Goold and Jones 1995). Because they spend large amounts of time at depth and use low frequency sound, sperm whales are likely to be susceptible to low frequency sound in the ocean (Croll et al. 1999).

Recordings of sperm whale vocalizations reveal that they produce a variety of sounds, such as clicks, gunshots, chirps, creaks, short trumpets, pips, squeals, and clangs (Goold 1999). Sperm whales typically produce short duration repetitive broadband clicks with frequencies below 100 Hz to greater than 30 kHz (Watkins 1977) and dominant frequencies between 1 to 6 kHz and 10 to 16 kHz. The SLs can reach 236 dB re: 1 µPa-m (Mohl et al. 2003). The clicks of neonate sperm whales are very different from typical clicks of adults in that they are of low directionality, long duration, and low frequency (between 300 Hz and 1.7 kHz) with estimated SLs between 140 to 162 dB re: 1 µPa at 1m (Madsen et al. 2003). Clicks are heard most frequently when sperm whales are engaged in diving and foraging behavior (Whitehead and Weilgart 1991; Miller et al. 2004). Creaks (rapid sets of clicks) are heard most frequently when sperm whales are foraging and engaged in the deepest portion of their dives, with inter-click intervals and SLs being altered during these behaviors (Miller et al. 2004; Laplanche et al. 2005).

When sperm whales are socializing, they tend to repeat series of group-distinctive clicks (codas), which follow a precise rhythm and may last for hours (Watkins and Schevill 1977). Codas are shared between individuals in a social unit and are considered to be primarily for intragroup communication (Weilgart and Whitehead 1997a; Rendell and Whitehead 2004). Recent research in the South Pacific Ocean suggests that in breeding areas the majority of codas are produced by mature females (Marcoux et al. 2006). Coda repertoires have also been found to vary geographically and are categorized as dialects, similar to those of killer whales (Weilgart and Whitehead 1997a; Pavan et al. 2000). For example, significant differences in coda repertoire have been observed between sperm whales in the Caribbean Sea and those in the Pacific Ocean (Weilgart and Whitehead 1997a). For example, significant differences in coda repertoire have been observed between sperm whales in the Caribbean Sea and those in the Pacific Ocean (Weilgart and Whitehead 1997a). Three coda types used by male sperm whales have recently

been described from data collected over multiple years: these codas associated with dive cycles, socializing, and alarm (Frantzis and Alexiadou 2008).

Direct measures of sperm whale hearing have been conducted on a stranded neonate using the auditory brainstem response technique: the whale showed responses to pulses ranging from 2.5 to 60 kHz and highest sensitivity to frequencies between five to 20 kHz (Ridgway and Carder 2001). Other hearing information consists of indirect data. For example, the anatomy of the sperm whale's inner and middle ear indicates an ability to best hear high-frequency to ultrasonic hearing (Ketten 1992a). The sperm whale may also possess better low-frequency than other odontocetes, although not as low as many baleen whales (Ketten 1992a). Reactions to anthropogenic sounds can provide indirect evidence of hearing capability, and several studies have made note of changes seen in sperm whale behavior in conjunction with these sounds. For example, sperm whales have been observed to frequently stop echolocating in the presence of underwater pulses made by echosounders and submarine sonar (Watkins and Schevill 1975b; Watkins et al. 1985b). In the Caribbean Sea, Watkins et al. (1985b) observed that sperm whales exposed to 3.25 to 8.4 kHz pulses (presumed to be from submarine sonar) interrupted their activities and left the area. Similar reactions were observed from artificial noise generated by banging on a boat hull (Watkins et al. 1985b). André et al. (1997) reported that foraging whales exposed to a 10 kHz pulsed signals did not ultimately exhibit any general avoidance reactions: when resting at the surface in a compact group, sperm whales initially reacted strongly, and then ignored the signal completely (André et al. 1997). Thode et al. (2007) observed that the acoustic signal from the cavitation of a fishing vessel's propeller (110 dB re: 1 μPa^2 between 250 Hz and 1 kHz) interrupted sperm whale acoustic activity and resulted in the animals converging on the vessel. The full range of functional hearing for the sperm whale is estimated to occur between approximately 150 Hz and 160 kHz, placing them among the group of cetaceans that can hear mid-frequency sounds (Southall et al. 2007b).

A sperm whale was tagged for a controlled exposure experiment during SOCAL BRS 2010. The sperm whale did not appear to demonstrate obvious behavioral changes in dive pattern or production of clicks (Southall et al. 2011b; Miller et al. 2012; Sivle et al. 2012).

Status

The sperm whale is endangered as a result of past commercial whaling. Although the aggregate abundance worldwide is probably at least several hundred thousand individuals, the extent of depletion and degree of recovery of populations are uncertain. Commercial whaling is no longer allowed, however, illegal hunting may occur at biologically unsustainable levels. Continued threats to sperm whale populations include ship strikes, entanglement in fishing gear, competition for resources due to overfishing, population, loss of prey and habitat due to climate change, and noise. The species' large population size shows that it is somewhat resilient to current threats.

Critical Habitat

No critical habitat has been designated for the sperm whale.

Recovery Goals

See the 2010 Final Recovery Plan for the sperm whale for complete downlisting/delisting criteria for both of the following recovery goals:

1. Achieve sufficient and viable populations in all ocean basins.
2. Ensure significant threats are addressed.

6.9 Hawaiian Monk Seal

The Hawaiian monk seal is a large phocid ("true seal") that is one of the rarest marine mammals in the world. The Hawaiian monk seal inhabits the Northwestern Hawaiian Islands and Main Hawaiian Islands (Figure 14).

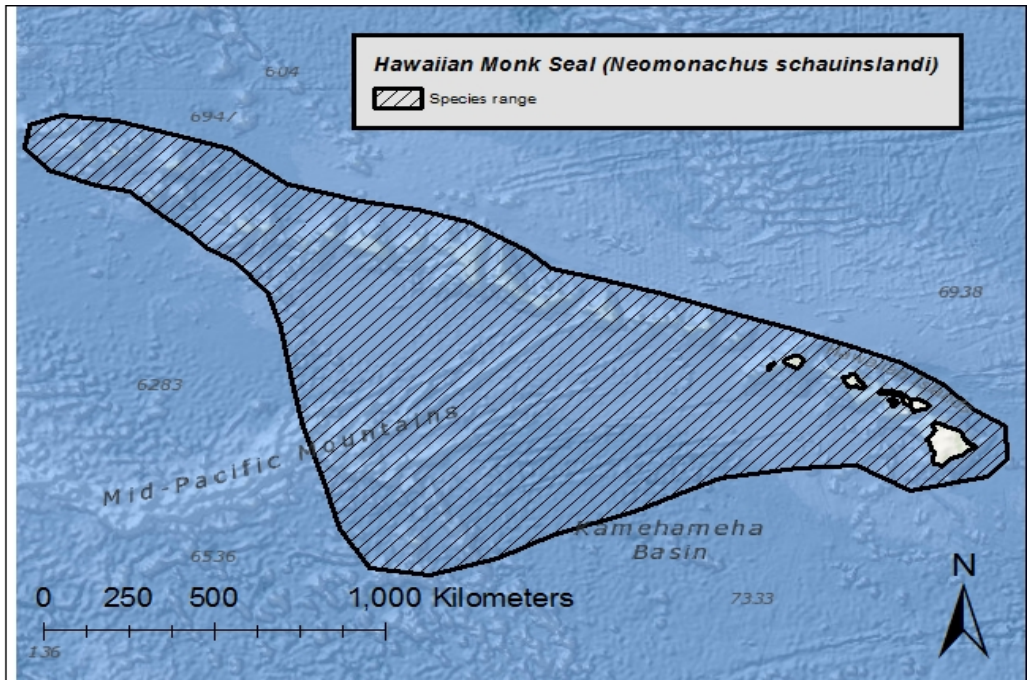

Figure 14. Map identifying the range of the endangered Hawaiian monk seal.

Hawaiian monk seals are silvery-grey with a lighter creamy coloration on their underside (newborns are black), they may also have light patches of red or green tinged coloration from attached algae. The Hawaiian monk seal was originally listed as endangered on November 23, 1976.

Information available from the recovery plan (NMFS 2007d), recent stock assessment report (Carretta et al. 2019), and status review (NMFS 2007b) were used to summarize the life history, population dynamics, and status of the species as follows.

Life History

Hawaiian monk seals can live, on average, 25 to 30 years. Sexual maturity in females is reached around five years of age and it is thought to be similar for males but they do not gain access to females until they are older. They have a gestation period of ten to eleven months, and calves nurse for approximately one month while the mother fasts and remains on land. After nursing, the mother abandons her pup and returns to sea for eight to ten weeks before returning to beaches to molt. Males compete in a dominance hierarchy to gain access to females (i.e., guarding them on shore). Mating occurs at sea, however, providing opportunity for female mate choice. Monk seals are considered foraging generalist that feed primarily on benthic and demersal prey such as fish, cephalopods, and crustaceans. They forage in sub-photic zones either because their areas host favorable prey items or because these areas are less accessible by competitors (Parrish et al. 2000).

Population Dynamics

The following is a discussion of the species' population and its variance over time. This section includes abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the Hawaiian monk seal.

The Hawaiian monk seal inhabits the Northwestern Hawaiian Islands and Main Hawaiian Islands. The entire range of the Hawaiian monk seal is located within U.S. waters. In addition to a small but growing population found on the Main Hawaiian Islands there are six main breeding sub-populations in the Northwestern Hawaiian Islands identified as: Kure Atoll, Midway Islands, Pearl and Hermes Reef, Lisianski Island, Laysan Island, and French Frigate Shoals. The latest published estimate of the total population of Hawaiian monk seals is 1,324 (Baker et al. 2016), although recently published data indicate a larger population estimate of 1,427 (NMFS 2018e). The most recent NMFS stock assessment report has a minimum abundance estimate of 1,205 animals (N=1,384) for all sites combined (Carretta et al. 2019). These estimates are the sum of the estimated abundances from the Northwestern Hawaiian Islands and the Main Hawaiian Islands.

The overall abundance of Hawaiian monk seals has declined by over 68 percent since 1958. Current estimates indicate a growth rate of approximately 6.5 percent annually for the Main Hawaiian Islands sub-population (Baker et al. 2011). Likewise, sporadic beach counts at Necker and Nihoa Islands suggest a positive growth rate. The six main Northwestern Hawaiian Islands sub-populations continue to decline at approximately 3.4 percent annually.

Genetic analysis indicates the species is a single panmictic population, thus warranting a single stock designation (Schultz et al. 2011). Genetic variation among monk seals is extremely low and may reflect a long-term history at low population levels and more recent human influences (Kretzmann et al. 2001; Schultz et al. 2009). In addition to low genetic variability, studies by Kretzmann et al. (1997) suggest the species is characterized by minimal genetic differentiation among sub-populations and, perhaps some naturally occurring local inbreeding. The potential for

genetic drift should have increased when seal numbers were reduced by European harvest in the 19th century, but any tendency for genetic divergence among sub-populations is probably mitigated by the inter-island movements of seals. However, since the population is so small there is concern about long-term maintenance of genetic diversity making it quite likely that this species will remain endangered for the foreseeable future.

Vocalization and Hearing

The information on the hearing capabilities of endangered Hawaiian monk seals is somewhat limited, but they appear to have their most sensitive hearing at 12 to 28 kHz. Below eight kHz, their hearing is less sensitive than that of other pinnipeds. Their sensitivity to high frequency sound drops off sharply above 30 kHz (Thomas et al. 1990b; Richardson et al. 1995a; Richardson et al. 1995g). An underwater audiogram for Hawaiian monk seal, based on a single animals whose hearing may have been affected by disease or age, was best at 12 to 28 kHz and 60 to 70 kHz (Thomas et al. 1990b). The hearing showed relatively poor hearing sensitivity, as well as a narrow range of best sensitivity and a relatively low upper frequency limit (Thomas et al. 1990b). Schusterman et al. (2000) reviewed available evidence on the potential for pinnipeds to echolocate and indicated that pinnipeds have not developed specialized sound production or reception systems required for echolocation. Instead, it appears pinnipeds have developed alternative sensory systems (e.g., visual, tactile) to effectively forage, navigate, and avoid predators underwater.

Status

Hawaiian monk seals were once harvested for their meat, oil, and skins, leading to extirpation in the main Hawaiian Islands and near-extinction of the species by the 20th century (Hiruki and Ragen 1992; Ragen 1999). The species partially recovered by 1960, when hundreds of seals were counted on northwestern Hawaiian Islands beaches. Since then, however, the species has declined in abundance. Though the ultimate cause(s) for the decline remain unknown threats include: food limitations in northwestern Hawaiian Islands, entanglement in marine debris, human interactions, loss of haul-out and pupping beaches due to erosion in northwestern Hawaiian Islands, disease outbreaks, shark predation, male aggression towards females, and low genetic diversity. With only 1,300 to 1,400 individuals remaining the species' resilience to further perturbation is low.

Critical Habitat

As stated in Section 5.5, Hawaiian monk seal critical habitat was originally designated on April 30, 1986, and extended on May 26, 1988. It includes all beach areas, sand spits, and islets (including all beach crest vegetation to its deepest extent inland), lagoon waters, inner reef waters, and ocean waters out to a depth of 37 m (121.4 ft) around the northwestern Hawaiian Islands breeding atolls and islands. The marine component of this habitat serves as foraging areas, while terrestrial habitat provides resting, pupping, and nursing habitat.

On September 21, 2015, NMFS published a final rule to revise designated critical habitat for Hawaiian monk seals, extending the designation in the northwestern Hawaiian Islands out to the 200 m (656.2 ft) depth contour (including Kure Atoll, Midway Islands, Pearl and Hermes Reef, Lisianski Island, Laysan Island, Maro Reef, Gardner Pinnacles, French Frigate Shoals, Necker Island, and Nihoa Island). It also designated six new areas in the main Hawaiian Islands (i.e., terrestrial and marine habitat from 5 m [16.4 ft] inland from the shoreline extending seaward to the 200 m (656.2 ft) depth contour around Kaula, Niihau, Kauai, Oahu, Maui, Nui, and Hawaii).

Recovery Goals

See the 2007 Final Recovery Plan for the Hawaiian monk seal for complete downlisting/delisting criteria for each of the four following recovery goals:

1. Improve the survivorship of females, particularly juveniles, in sub-populations of the northwestern Hawaiian Islands.
2. Maintain the extensive field presence during the breeding season in the northwestern Hawaiian Islands.
3. Ensure the continued natural growth of the Hawaiian monk sea in the Main Hawaiian Islands by reducing threats including interactions with recreational fisheries, disturbance of mother-pup pairs, disturbance of hauled out seals, and exposure to human domestic animal diseases.
4. Reduce the probability of the introduction of infectious diseases into the Hawaiian monk seal population.

6.10 Spotted Seal – Southern Distinct Population Segment

Spotted seals in the Pacific are distributed from 85° North south to Sakhalin Island (45° North), including the Chukchi, Bering, and Okhotsk Seas. Eight breeding areas throughout the range of the spotted seal have been identified (Figure 15).

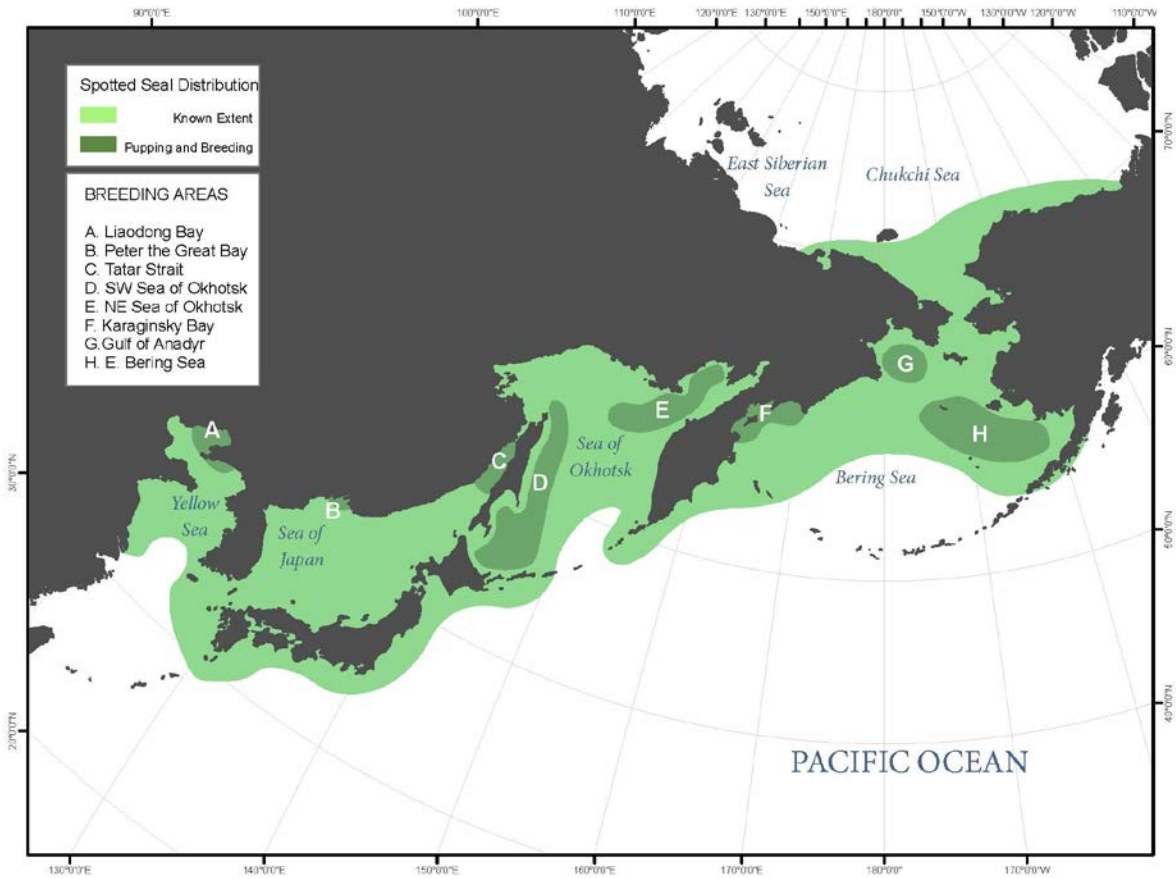

Figure 15. Map identifying the range, pupping, and breeding areas of the spotted seal. Breeding areas A and B (Liaodong Bay and Peter the Great Bay) comprise the Southern distinct population segment of spotted seal (Boveng et al. 2009a).

Spotted seals have a silver to light gray coat with dark spots. Adult can be up to 1.5 m (5 ft) and weigh between 65 to 115 kg (140 to 250 lb). The spotted seal is divided into three DPSs: the Southern DPS, the Bering Sea DPS, and the Sea of Okhotsk DPS. The Southern DPS is composed of spotted seals breeding in the Liaodong Bay, Yellow Sea, and Peter the Great Bay in the Sea of Japan. On October 22, 2010, the NMFS issued a final determination to list the Southern DPS as threatened under the ESA (Table 12).

We used information available in the final ESA-listing, the status review (Boveng et al. 2009a) and available literature to summarize the status of the Southern DPS of spotted seal, as follows.

Life History

Spotted seals can live up to 30 to 35 years old. Most spotted seals are sexually mature by age four. Spotted seals haulout onto the sea ice to breed; the timing of breeding depends on the region. Breeding in Liaodong Bay occurs from February to mid-March and in March and April in the Peter the Great Bay. The implantation of the fertilized embryo is delayed by two to four months, and gestation lasts seven to nine months. Pups are born between early January to mid-February in Liaodong Bay, and between early February and mid-March in peter the Great Bay.

Pups are usually weaned in three to four weeks. Nursing pups do not enter the water until they are weaned and molted. They are dependent on the sea ice until they learn to dive and forage for themselves, which usually occurs ten to 15 days after molting. After breeding and birthing, the herds break up to migrate in spring and summer towards open water for favorable foraging grounds. Adult spotted seals forage on a wide variety of fishes like Pacific herring, Japanese smelt and capelin. Juveniles eat krill and small crustaceans. While foraging, spotted seals generally stay in continental shelf waters up to 200 m (656.2 ft) deep (Boveng et al. 2009a).

Population Dynamics

The following is a discussion of the species' population and its variance over time. This section includes abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the Southern DPS of the spotted seal.

Due to the logistical difficulties of surveying ice seals in remote areas, there is some uncertainty surrounding abundance estimates for the Southern DPS of spotted seal. For the Southern DPS as a whole, the population could number as many as 3,500 individuals. The breeding population in Liaodong Bay was estimated at 1,000 individuals from 2005 through 2008 (Han et al. 2010) and about 800 individuals in 2007 (Boveng et al. 2009a). The most recent abundance estimate for the Peter the Great Bay breeding population is 2,500 spotted seals in the spring, with about 300 pups produced annually (Boveng et al. 2009a).

Population trends are not available at this time for the Southern DPS of spotted seal. Available information for the breeding population in Liaodong Bay indicate that the population there has fluctuated from a maximum of 8,137 individuals in 1940 to as few as 700 in 2007 (75 FR 65239).

There has been some study of the population structure of Southern DPS of spotted seals. (Han et al. 2010) found low levels of genetic diversity in the Liaodong Bay breeding colony, likely the result of a population reduction over the past several decades.

Spotted seals are found in the North Pacific Ocean, preferring arctic and sub-arctic waters and are closely associated with outer margins of sea ice. Spotted seals in the Southern DPS are found in the Yellow Sea and Sea of Japan (Figure 15). Most seals move seasonally, following the extent of the sea ice.

Vocalization and Hearing

Five distinct sounds have been identified in captive spotted seals of both sexes: growls, drums, snorts, chirps, and barks that range in frequency from 500 Hz to 3.5 kHz (Beier and Wartzok 1979; Richardson et al. 1995a). A "creaky door sound" has only been recorded from males (Beier and Wartzok 1979). A recent study on wild spotted seals in Liaodong Bay, China identified four major call types (knocks, growls, drums, and seeps), some of which are similar to those previously mentioned for captive animals (Yang et al. 2017). These calls also appeared to be similar to the closely related harbor seal (*Phoca vitulina*), and consist of short, low frequency

(less than 600 Hz) sounds (Yang et al. 2017). Little is known about the hearing of spotted seals. Recently, Sills et al. (2014) measured the underwater and in-air hearing capabilities of young spotted seals and found that the best hearing sensitivity in air spanned four octaves, ranging from approximately 0.6 to 11 kHz, while the hearing sensitivity underwater ranged from 0.3 and 56 kHz. Sills et al. (2014) concluded that the sound reception capabilities of spotted seals differ from those described previously for ice seals, with capabilities more similar to harbor seals.

Status

Commercial harvesting in the 19th and 20th centuries depleted Southern DPS of spotted seals. In Peter the Great Bay, as many as 80 or more spotted seals per day were harvested in the late 19th century. Populations in Liaodong Bay were also heavily impacted by hunting; about 30,000 spotted seals were harvested in the Yellow Sea from 1930 through 1990 (Boveng et al. 2009a). Bycatch in fishing nets and shooting by fishermen are considered to be the greatest current threats to Southern DPS of spotted seals. In addition, the species is threatened by future climate change, specifically the loss of essential sea ice and change in prey availability. Even though spotted seals in Liaodong Bay and Peter the Great Bay can breed and molt on land, a loss of sea ice habitat will reduce suitable space for reproduction and rearing. As a result, is likely to become endangered in the future.

Critical Habitat

No designated critical habitat for the Southern DPS of spotted seal; NMFS cannot designate critical habitat in foreign waters.

Recovery Goals

NMFS has not prepared a Recovery Plan for the Southern DPS of spotted seal. In general, ESA-listed species which occur entirely outside U.S. jurisdiction are not likely to benefit from recovery plans (55 FR 24296).

6.11 Steller Sea Lion – Western Distinct Population Segment

The Steller sea lion ranges from Japan, through the Okhotsk and Bering Seas, to central California. It consists of two morphologically, ecologically, and behaviorally separate DPSs: the Eastern, which includes sea lions in Southeast Alaska, British Columbia, Washington, Oregon, and California; and the Western, which includes sea lions in all other regions of Alaska, as well as Russia and Japan (Figure 16).

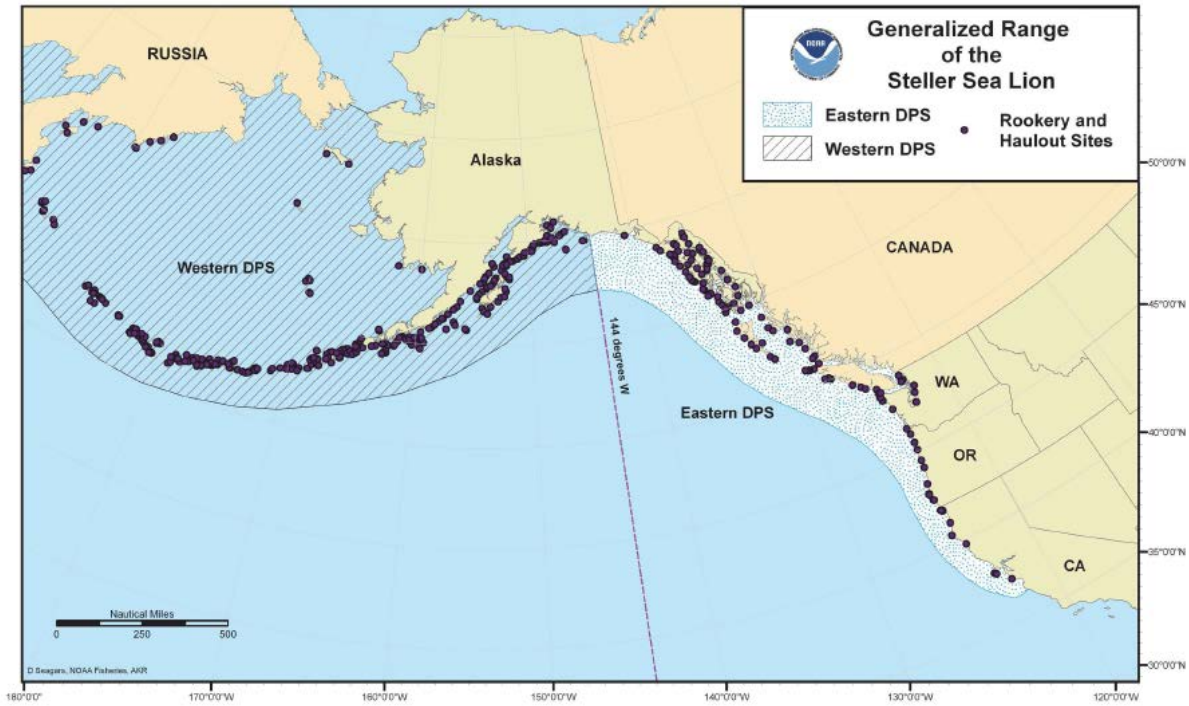

Figure 16. Map identifying the range of the endangered Western distinct population segment of Steller sea lion.

Steller sea lion adults are light blonde to reddish brown and slightly darker on the chest and abdomen. At the time of their initial ESA-listing, Steller sea lions were considered a single population listed as threatened. On May 5, 1997, following a status review, NMFS established two DPSs of Steller sea lions, and issued a final determination to list the Western DPS as endangered under the ESA. The Eastern DPS was delisted on November 4, 2013, and the Western DPS retained its endangered status (78 FR 66139) (Table 12).

We used information available in the final ESA-listing, the revised Recovery Plan (NMFS 2008b), and the most recent stock assessment report (Muto et al. 2019) to summarize the status of the Western DPS of Steller sea lions, as follows.

Life History

Within the Western DPS of Steller sea lions, pupping and breeding occurs at numerous major rookeries from late May to early July. Male Steller sea lions become sexually mature at three to seven years of age. They are polygynous, competing for territories and females by age ten or eleven. Female Steller sea lions become sexually mature at three to six years of age and reproduce into their early 20’s. Most females breed annually, giving birth to a single pup. Pups are usually weaned in one to two years. Females and their pups disperse from rookeries by August to October. Juveniles and adults disperse widely, especially males. Their large aquatic ranges are used for foraging, resting, and traveling. Steller sea lions forage on a wide variety of demersal, semi-demersal, and pelagic prey, including fish and cephalopods. Some prey species

form large seasonal aggregations, including endangered salmon and eulachon species. Others are available year round.

Population Dynamics

The following is a discussion of the species' population and its variance over time. This section includes abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the Western DPS of the Steller sea lion.

As of 2017, the best estimate of abundance of the Western DPS of Steller sea lion in Alaska was 11,952 pups and 42,315 for non-pups (total N_{min}= 54,267) (Muto et al. 2019). This represents a large decline since counts in the 1950s (N=140,000) and 1970s (N=110,000).

Steller sea lion Western DPS site counts decreased 40 percent from 1991 through 2000, an average annual decline of 5.4 percent; however, counts increased three percent between 2004 through 2008, the first recorded population increase since the 1970s (NMFS 2008b). Overall, there are strong regional differences across the range in Alaska, with positive trends in the Gulf of Alaska and eastern Bering Sea east of Samalga Pass (~170°W) and generally negative trends to the west in the Aleutian Islands. Non-pup trends in 2002- 2017 in Alaska have a longitudinal gradient with highest rates of increase generally in the east (eastern Gulf of Alaska) and steadily decreasing rates to the west.

Based on the results of genetic studies, the Steller sea lion population was reclassified into two DPSs: Western and Eastern. The data which came out of these studies indicated that the two populations had been separate since the last ice age (Bickham et al. 1998). Further examination of the Steller sea lions from the Gulf of Alaska (i.e., the Western DPS) revealed a high level of haplotypic diversity, indicating that genetic diversity had been retained despite the decline in abundance (Bickham et al. 1998). There is an exchange of sea lions across the stock boundary, especially due to the wide-ranging seasonal movements of juveniles and adult males (Jemison et al. 2013). During the breeding season, sea lions, especially adult females, typically return to their natal rookery, or a nearby breeding rookery to breed and pup (Hastings et al. 2017). However, mixing of mostly breeding females from Prince William Sound to Southeast Alaska began in the 1990s and two new, mixed-stock rookeries were established (O'corry-Crowe et al. 2011; Jemison et al. 2013).

Steller sea lions are distributed mainly around the coasts to the outer continental shelf along the North Pacific Ocean rim from northern Hokkaido, Japan through the Kuril Islands and Okhotsk Sea, Aleutian Islands and central Bering Sea, southern coast of Alaska and south to California (Figure 16). The Western DPS includes Steller sea lions that reside in the central and western Gulf of Alaska, Aleutian Islands, as well as those that inhabit the coastal waters and breed in Asia (e.g., Japan and Russia).

Vocalization and Hearing

In underwater environments, Steller sea lions hear within the range of 0.5 to 32 kHz for males and from 4 to 32 kHz for females (Kastelein et al. 2005). Males and females apparently have different underwater hearing sensitivities, with males hearing best at 1 to 16 kHz (best sensitivity at the low end of the range) and females having a maximum sensitivity at 25 kHz (best hearing at the upper end of the range) (Kastelein et al. 2005).

Status

The species was ESA-listed as threatened in 1990 because of significant declines in population sizes for unknown reasons that are not explained by the documented level of direct human-caused mortality and serious injury. At the time, the major threat to the species was thought to be reduction in prey availability. To protect and recover the species, NMFS established the following measures: prohibition of shooting at or near Steller sea lions; prohibition of vessel approach to within 5.6 km (3 nmi) of specific rookeries, within 0.8 km (0.4 nmi) of land, and within sight of other listed rookeries; and restriction of incidental fisheries take to 675 Steller sea lions annually in Alaskan waters.

The minimum mean annual U.S. commercial fishery-related mortality and serious injury rate (40 sea lions) is more than 10% of the PBR (10% of PBR = 33) and, therefore, not be considered insignificant and approaching a zero mortality and serious injury rate. Based on available data, the total estimated annual level of human-caused mortality and serious injury (252 sea lions) is below the PBR level (326) for this stock (Muto et al. 2019).

There are key uncertainties in the assessment of the Western U.S. stock of Steller sea lions. Some genetic studies support the separation of Steller sea lions in western Alaska from those in Russia; population numbers in this assessment are only from the U.S. to be consistent with the geographic range of information on mortality and serious injury. There is some overlap in range between animals in the western and eastern stocks in northern Southeast Alaska. The population abundance is based on counts of visible animals; the calculated NMIN and PBR levels are conservative because there are no data available to correct for animals not visible during the visual surveys. There are multiple nearshore commercial fisheries which are not observed; thus, there is likely to be unreported fishery-related mortality and serious injury of Steller sea lions. Estimates of human-caused mortality and serious injury from stranding data are underestimates because not all animals strand nor are all stranded animals found, reported, or have the cause of death determined. Several factors may have been important drivers of the decline of the stock. However, there is uncertainty about threats currently impeding their recovery, particularly in the Aleutian Islands (Muto et al. 2019).

Critical Habitat

In 1997, NMFS designated critical habitat for the Steller sea lion. The designated critical habitat includes specific rookeries, haul-outs, and associated areas, as well as three foraging areas that are considered to be essential for health, continued survival, and recovery of the species.

Figure 17. Map depicting Alaskan designated critical habitat for the Western distinct population segment of Steller sea lion.

In Alaska, areas include major Steller sea lion rookeries, haul-outs and associated terrestrial, air, and aquatic zones (Figure 17). Designated critical habitat includes a terrestrial zone extending 0.9 km (0.5 nmi) landward from each major rookery and haul-out; it also includes air zones extending 0.9 km above these terrestrial zones and aquatic zones. Aquatic zones extend 0.9 km (0.5 nmi) seaward from the major rookeries and haul-outs east of 144° West. In addition, NMFS designated special aquatic foraging areas as critical habitat for the Steller sea lion. These areas include the Shelikof Strait (in the Gulf of Alaska), Bogoslof Island, and Seaguam Pass (the latter two are in the Aleutians). These sites are located near Steller sea lion abundance centers and include important foraging areas, large concentrations of prey, and host large commercial fisheries that often interact with the species.

Although within the range of the now delisted Eastern DPS, the designated critical habitat in California and Oregon remains in effect (78 FR 66139). In California and Oregon, major Steller sea lion rookeries and associated air and aquatic zones are designated as critical habitat. Designated critical habitat includes an air zone extending 0.9 km (0.5 nmi) above rookery areas historically occupied by Steller sea lions. Designated critical habitat also includes an aquatic zone extending 0.9 km (0.5 nmi) seaward.

Recovery Goals

See the 2008 Revised Recovery Plan for the Steller sea lion for complete downlisting/delisting criteria for each of the following recovery goals:

1. Baseline population monitoring.
2. Insure adequate habitat and range for recovery
3. Protect from over-utilization for commercial, recreational, scientific, or educational purposes.
4. Protect from diseases, contaminants, and predation.
5. Protect from other natural or anthropogenic actions and administer the recovery program.

6.12 Green Turtle – Central North Pacific Distinct Population Segment

The green turtle is globally distributed and commonly inhabits nearshore and inshore waters, occurring throughout tropical, sub-tropical and, to a lesser extent, temperate waters (Figure 18).

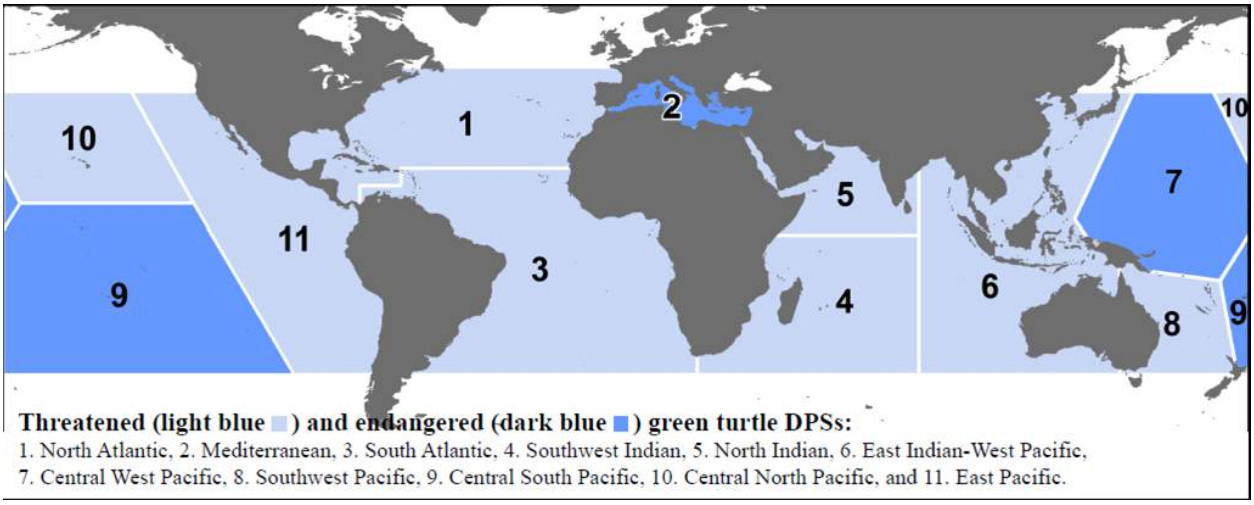

Figure 18. Map depicting range and distinct population segment boundaries for green turtles.

The Central North Pacific DPS of green turtle is found in the Pacific Ocean near the Hawaiian Archipelago and Johnston Atoll Figure 19).

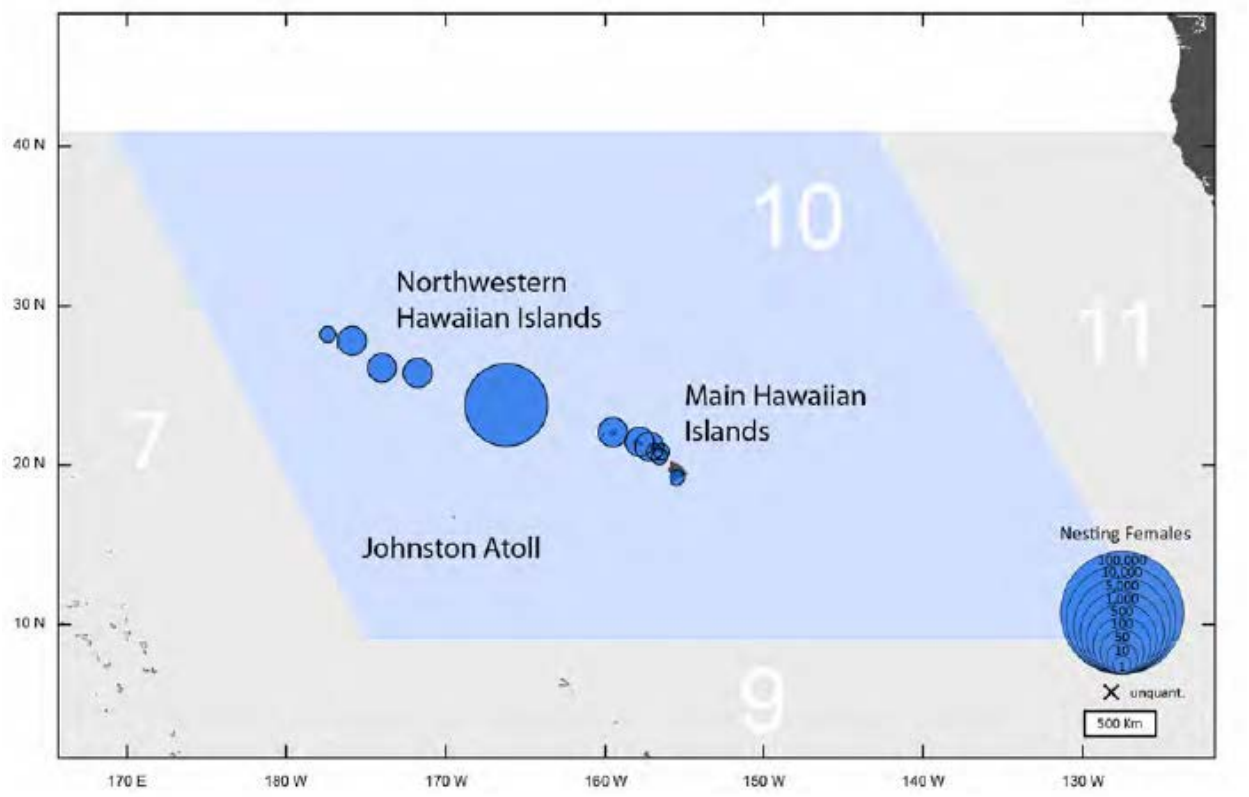

Figure 19. Geographic range of the Central North Pacific distinct population segment of green turtle, with location and abundance of nesting females (Seminoff et al. 2015).

The green turtle is the largest of the hardshell sea turtles, growing to a weight of 158.8 kg (350 lb) and a straight carapace length of greater than 1 m (3.3 ft). The species was listed under the ESA on July 28, 1978 (43 FR 32800). The species was separated into two ESA-listing designations: endangered for breeding populations in Florida and the Pacific coast of Mexico and threatened in all other areas throughout its range. On April 6, 2016, NMFS listed eleven DPSs of green turtles as threatened or endangered under the ESA. The Central North Pacific DPS is ESA-listed as threatened.

We used information available in the 2007 Five Year Review (USFWS 2007) and 2015 Status Review (Seminoff et al. 2015) to summarize the life history, population dynamics, and status of the species as follows.

Life History

Age at first reproduction for females is 20 to 40 years. Green turtles lay an average of three nests per season with an average of 100 eggs per nest. The remigration interval (i.e., return to natal beaches) is two to five years. Nesting occurs primarily on beaches with intact dune structure, native vegetation, and appropriate incubation temperatures during summer months. After emerging from the nest, hatchlings swim to offshore areas and go through a post-hatchling

pelagic stage where they are believed to live for several years. During this life stage, green turtles feed close to the surface on a variety of marine algae and other life associated with drift lines and debris. Adult sea turtles exhibit site fidelity and migrate hundreds to thousands of kilometers from nesting beaches to foraging areas. Green turtles spend the majority of their lives in coastal foraging grounds, which include open coastlines and protected bays and lagoons. Adult green turtles feed primarily on seagrasses and algae, although they also eat jellyfish, sponges, and other invertebrate prey.

Population Dynamics

The following discussion of the species' population and its variance over time. This section includes abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the Central North Pacific DPS of green turtle.

The green turtle occupies the coastal waters of over 140 countries worldwide; nesting occurs in more than 80 countries. Worldwide, nesting data at 464 sites indicate that 563,826 to 564,464 females nest each year (Seminoff et al. 2015). There are 13 known nesting sites for the Central North Pacific DPS, with an estimated 3,846 nesting females. The DPS is very thoroughly monitored, and it is believed there is little chance that there are undocumented nesting sites. The largest nesting site is at French Frigate Shoals, Hawaii, which hosts 96 percent of the nesting females for the Central North Pacific DPS (Seminoff et al. 2015). Nesting surveys have been conducted since 1973. Nesting abundance at East Island, French Frigate Shoals, increases at 4.8 percent annually (Seminoff et al. 2015).

The majority of nesting for the Central North Pacific DPS is centered at one site on French Frigate Shoals, and there is little diversity in nesting areas. Overall, the Central North Pacific DPS has a relatively low level of genetic diversity and stock sub-structuring (Seminoff et al. 2015).

The green turtle has a circumglobal distribution, occurring throughout nearshore tropical, sub-tropical and, to a lesser extent, temperate waters (Seminoff et al. 2015). Green turtles in the Central North Pacific DPS are found in the Hawaiian Archipelago and Johnston Atoll (Figure 19). The major nesting site for the Central North Pacific DPS is at East Island, French Frigate Shoals, in the Northwestern Hawaiian Islands; lesser nesting sites are found throughout the Northwestern Hawaiian Islands and the Main Hawaiian Islands.

Many nesting sites worldwide suffer from a lack of consistent, standardized monitoring, making it difficult to characterize population growth rates for a DPS.

Vocalization and Hearing

Sea turtles are low frequency hearing specialists, typically hearing frequencies from 30 Hz to 2 kHz, with a range of maximum sensitivity between 100 to 800 Hz (Ridgway et al. 1969; Lenhardt 1994; Bartol et al. 1999b; Lenhardt 2002; Moein Bartol and Ketten 2006). Piniak et al. (2012) found green turtle juveniles capable of hearing underwater sounds at frequencies of 50 Hz

to 1,600 kHz (maximum sensitivity at 200 to 400 Hz). Hearing below 80 Hz is less sensitive but still possible (Lenhardt 1994). Based upon auditory brainstem responses green turtles have been measured to hear in the 50 Hz to 1.6 kHz range (Dow et al. 2008), with greatest response at 300 Hz (Yudhana et al. 2010); a value verified by Moein Bartol and Ketten (2006). Other studies have found greatest sensitivities are 200 to 400 Hz for the green turtle with a range of 100 to 500 Hz (Ridgway et al. 1969; Moein Bartol and Ketten 2006) and around 250 Hz or below for juveniles (Bartol et al. 1999b). However, Dow et al. (2008) found best sensitivity between 50 and 400 Hz.

These hearing sensitivities are similar to those reported for two terrestrial species: pond and wood turtles. Pond turtles respond best to sounds between 200 to 700 Hz, with slow declines below 100 Hz and rapid declines above 700 Hz, and almost no sensitivity above 3 kHz (Wever and Vernon 1956). Wood turtles are sensitive up to about 500 Hz, followed by a rapid decline above 1 kHz and almost no responses beyond 3 to 4 kHz (Patterson 1966).

Status

Once abundant in tropical and sub-tropical waters, green turtles worldwide exist at a fraction of their historical abundance, as a result of over-exploitation. Globally, egg harvest, the harvest of females on nesting beaches and directed hunting of sea turtles in foraging areas remain the three greatest threats to their recovery. In addition, bycatch in drift-net, long-line, set-net, pound-net, and trawl fisheries kill thousands of green turtles annually. Increasing coastal development (including beach erosion and re-nourishment, construction and artificial lighting) threatens nesting success and hatchling survival. On a regional scale, the different DPSs experience these threats as well, to varying degrees. Differing levels of abundance combined with different intensities of threats and effectiveness of regional regulatory mechanisms make each DPS uniquely susceptible to future perturbations.

Green turtles in the Hawaiian Archipelago were subjected to hunting pressure for subsistence and commercial trade, which was largely responsible for the decline in the region. Though the practice has been banned, there are still anecdotal reports of harvest. Incidental bycatch in fishing gear, ingestion of marine debris, and the loss of nesting habitat due to sea level rise are current threats to the population. Although these threats persist, the increase in annual nesting abundance, continuous scientific monitoring, legal enforcement and conservation programs are all factors that favor the resiliency of the Central North Pacific DPS of green turtle.

Critical Habitat

No critical habitat has been designated for the Central North Pacific DPS of green turtle.

Recovery Goals

See the 1998 and 1991 recovery plans for the Pacific, East Pacific, and Atlantic populations of green turtles for complete downlisting/delisting criteria for recovery goals for the species. Broadly, recovery plan goals emphasize the need to protect and manage nesting and marine

habitat, protect and manage populations on nesting beaches and in the marine environment, increase public education, and promote international cooperation on sea turtle conservation topics.

6.13 Green Turtle – East Indian – West Pacific Distinct Population Segment

The green turtle is globally distributed and commonly inhabits nearshore and inshore waters, occurring throughout tropical, sub-tropical and, to a lesser extent, temperate waters (Figure 18). The East Indian-West Pacific DPS of green turtle is found in the Indian Ocean from Southeast Asia through Western Australia (Figure 20).

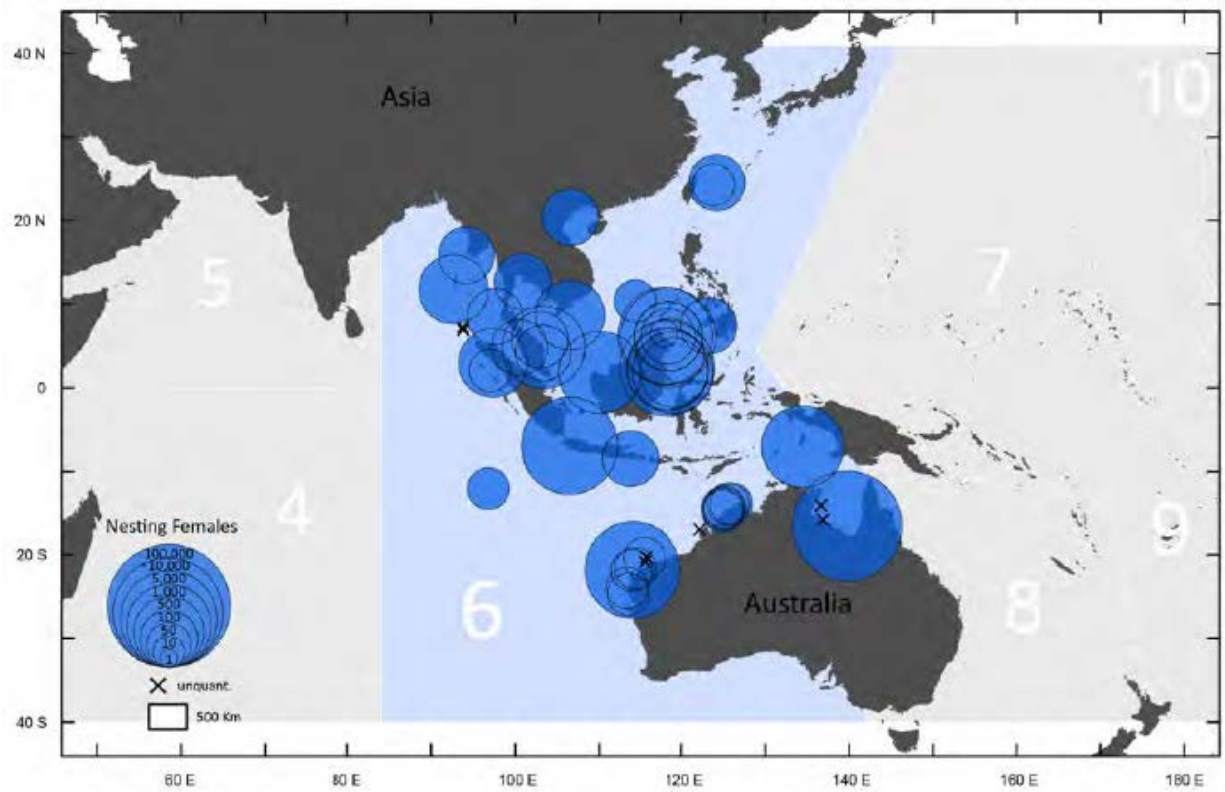

Figure 20. Geographic range of the East Indian-West Pacific distinct population segment of green turtle, with location and abundance of nesting females (Seminoff et al. 2015).

The green turtle is the largest of the hardshell sea turtles, growing to a weight of 158.8 kg (350 lb) and a straight carapace length of greater than 1 m (3.3 ft). The species was listed under the ESA on July 28, 1978 (43 FR 32800). The species was separated into two ESA-listing designations: endangered for breeding populations in Florida and the Pacific coast of Mexico and threatened in all other areas throughout its range. On April 6, 2016, NMFS listed eleven DPSs of green turtles as threatened or endangered under the ESA. The East Indian-West Pacific DPS is ESA-listed as threatened.

We used information available in the 2007 Five Year Review (USFWS 2007) and 2015 Status Review (Seminoff et al. 2015) to summarize the life history, population dynamics, and status of the species as follows.

Life History

Age at first reproduction for females is 20 to 40 years. Green turtles lay an average of three nests per season with an average of 100 eggs per nest. The remigration interval (i.e., return to natal beaches) is two to five years. Nesting occurs primarily on beaches with intact dune structure, native vegetation, and appropriate incubation temperatures during summer months. After emerging from the nest, hatchlings swim to offshore areas and go through a post-hatchling pelagic stage where they are believed to live for several years. During this life stage, green turtles feed close to the surface on a variety of marine algae and other life associated with drift lines and debris. Adult sea turtles exhibit site fidelity and migrate hundreds to thousands of kilometers from nesting beaches to foraging areas. Green turtles spend the majority of their lives in coastal foraging grounds, which include open coastlines and protected bays and lagoons. Adult green turtles feed primarily on seagrasses and algae, although they also eat jellyfish, sponges, and other invertebrate prey.

Population Dynamics

The following discussion of the species' population and its variance over time. This section includes abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the East Indian-West Pacific DPS of green turtle.

The green turtle occupies the coastal waters of over 140 countries worldwide; nesting occurs in more than 80 countries. Worldwide, nesting data at 464 sites indicate that 563,826 to 564,464 females nest each year (Seminoff et al. 2015). There are 58 nesting sites for the East Indian-West Pacific DPS, with a total nester abundance estimated at 77,099. The largest nesting site is the Wellesley Group, three islands in the Gulf of Carpentaria off northern Australia. This group hosts 32 percent of the nesting females for the East Indian-West Pacific DPS (Seminoff et al. 2015).

There are no estimates of population growth for the East Indian-West Pacific DPS. There is variation in the nesting abundance trends across nesting sites, with some showing increase while others are decreasing. Broadly though, there is a decrease in nesting females throughout the DPS with the exception of Malaysia and the Philippines showing an increase, attributed to successful conservation efforts (Seminoff et al. 2015).

Genetic studies have been conducted on over 22 of 58 rookeries in the East Indian-West Pacific DPS, revealing a complex population structure. Sixteen regional genetic stocks have been identified, with a few common and widespread haplotypes throughout the region. Rare or unique haplotypes are present at most rookeries (Seminoff et al. 2015).

The green turtle has a circumglobal distribution, occurring throughout nearshore tropical, sub-tropical and, to a lesser extent, temperate waters (Seminoff et al. 2015). The East Indian-West Pacific DPS comprises nesting sites in Northern Australia, Indonesia, Malaysia, Peninsular Malaysia, and the Philippine Turtle Islands. The East Indian-West Pacific DPS is spread throughout the eastern Indian Ocean, east of Sri Lanka, south to western and northern Australia, Indonesia, Malaysia, and Taiwan, and north to Japan.

Many nesting sites worldwide suffer from a lack of consistent, standardized monitoring, making it difficult to characterize population growth rates for a DPS.

Vocalization and Hearing

Sea turtles are low frequency hearing specialists, typically hearing frequencies from 30 Hz to 2 kHz, with a range of maximum sensitivity between 100 Hz to 800 Hz (Ridgway et al. 1969; Lenhardt 1994; Bartol et al. 1999b; Lenhardt 2002; Moein Bartol and Ketten 2006). Piniak et al. (2012) found green turtle juveniles capable of hearing underwater sounds at frequencies of 50 Hz to 1,600 kHz (maximum sensitivity at 200 to 400 Hz). Hearing below 80 Hz is less sensitive but still possible (Lenhardt 1994). Based upon auditory brainstem responses green turtles have been measured to hear in the 50 Hz to 1.6 kHz range (Dow et al. 2008), with greatest response at 300 Hz (Yudhana et al. 2010); a value verified by Moein Bartol and Ketten (2006). Other studies have found greatest sensitivities are 200 to 400 Hz for the green turtle with a range of 100 to 500 Hz (Ridgway et al. 1969; Moein Bartol and Ketten 2006) and around 250 Hz or below for juveniles (Bartol et al. 1999b). However, Dow et al. (2008) found best sensitivity between 50 and 400 Hz.

These hearing sensitivities are similar to those reported for two terrestrial species: pond and wood turtles. Pond turtles respond best to sounds between 200 to 700 Hz, with slow declines below 100 Hz and rapid declines above 700 Hz, and almost no sensitivity above 3 kHz (Wever and Vernon 1956). Wood turtles are sensitive up to about 500 Hz, followed by a rapid decline above 1 kHz and almost no responses beyond 3 to 4 kHz (Patterson 1966).

Status

Once abundant in tropical and sub-tropical waters, green turtles worldwide exist at a fraction of their historical abundance, as a result of over-exploitation. Globally, egg harvest, the harvest of females on nesting beaches and directed hunting of sea turtles in foraging areas remain the three greatest threats to their recovery. In addition, bycatch in drift-net, long-line, set-net, pound-net, and trawl fisheries kill thousands of green turtles annually. Increasing coastal development (including beach erosion and re-nourishment, construction and artificial lighting) threatens nesting success and hatchling survival. On a regional scale, the different DPSs experience these threats as well, to varying degrees. Differing levels of abundance combined with different intensities of threats and effectiveness of regional regulatory mechanisms make each DPS uniquely susceptible to future perturbations.

The East Indian-West Pacific DPS of green turtle is relatively large, though it has been reduced from historic levels due to overutilization for commercial and subsistence purposes. Green turtles and their eggs are still harvested for consumption in some areas. Other current threats to the East Indian-West Pacific DPS of green turtle include mortality from incidental bycatch, and predation by feral pigs, dogs, and foxes.

Critical Habitat

No critical habitat has been designated for the East Indian-West Pacific DPS of green turtle. NMFS cannot designate critical habitat in foreign waters.

Recovery Goals

NMFS has not prepared a Recovery Plan for the East Indian-West Pacific DPS of green turtle. In general, ESA-listed species which occur entirely outside U.S. jurisdiction are not likely to benefit from recovery plans (55 FR 24296).

6.14 Green Turtle – North Indian Distinct Population Segment

The green turtle is globally distributed and commonly inhabits nearshore and inshore waters, occurring throughout tropical, sub-tropical and, to a lesser extent, temperate waters (Figure 18). The North Atlantic DPS of green turtle is found in the North Indian Ocean from the east coast of Africa, around the Arabian Peninsula to the west coast of India (Figure 21).

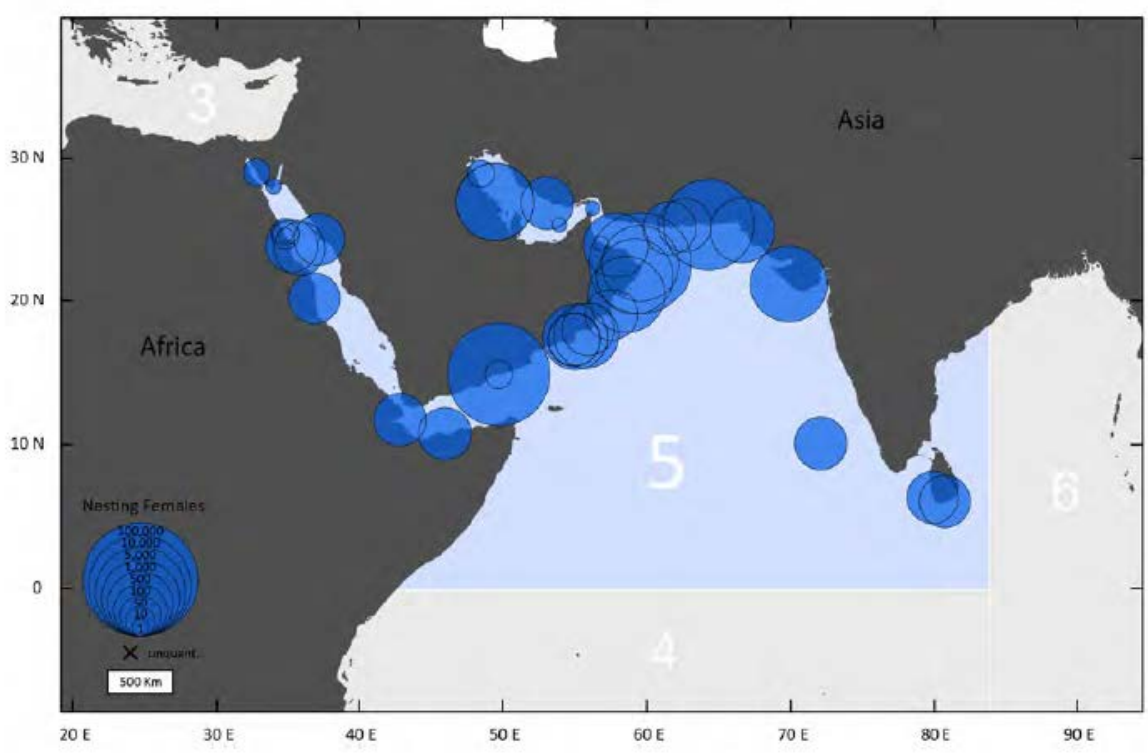

Figure 21. Geographic range of the North Indian distinct population segment of green turtle, with location and abundance of nesting females (Seminoff et al. 2015).

The green turtle is the largest of the hardshell sea turtles, growing to a weight of 158.8 kg (350 lb) and a straight carapace length of greater than 1 m (3.3 ft). The species was listed under the ESA on July 28, 1978 (43 FR 32800). The species was separated into two ESA-listing designations: endangered for breeding populations in Florida and the Pacific coast of Mexico and threatened in all other areas throughout its range. On April 6, 2016, NMFS listed eleven DPSs of green turtles as threatened or endangered under the ESA. The North Indian DPS is ESA-listed as threatened.

We used information available in the 2007 Five Year Review (USFWS 2007) and 2015 Status Review (Seminoff et al. 2015) to summarize the life history, population dynamics, and status of the species as follows.

Life History

Age at first reproduction for females is 20 to 40 years. Green turtles lay an average of three nests per season with an average of 100 eggs per nest. The remigration interval (i.e., return to natal beaches) is two to five years. Nesting occurs primarily on beaches with intact dune structure, native vegetation, and appropriate incubation temperatures during summer months. After emerging from the nest, hatchlings swim to offshore areas and go through a post-hatchling pelagic stage where they are believed to live for several years. During this life stage, green turtles feed close to the surface on a variety of marine algae and other life associated with drift lines and debris. Adult sea turtles exhibit site fidelity and migrate hundreds to thousands of kilometers from nesting beaches to foraging areas. Green turtles spend the majority of their lives in coastal foraging grounds, which include open coastlines and protected bays and lagoons. Adult green turtles feed primarily on seagrasses and algae, although they also eat jellyfish, sponges, and other invertebrate prey.

Population Dynamics

The following discussion of the species' population and its variance over time. This section includes abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the North Indian DPS of green turtle.

The green turtle occupies the coastal waters of over 140 countries worldwide; nesting occurs in more than 80 countries. Worldwide, nesting data at 464 sites indicate that 563,826 to 564,464 females nest each year (Seminoff et al. 2015). Two of the world's largest green turtle nesting sites – in Yemen and Oman – are in the North Indian DPS. There are 38 nesting sites for the North Indian DPS, with a nester abundance estimated at 55,243. The largest nesting site is at Ras Sharma, Yemen, hosting 33 percent of nesting females for the North Indian DPS (Seminoff et al. 2015).

There are no estimates of population growth for the North Indian DPS. Long-term trend data is lacking for all nesting sites in the North Indian DPS, and only nine sites out of 38 have ten or more years of recent data. Even in those cases, there is often a lack of standardization in sampling, making it difficult to understand and ascertain trends. Generally though, nesting sites in Oman represent one of the largest and most important nesting concentrations for green turtles worldwide, with approximately 44,000 nests recorded in 2005, compared to about 6,000 nesting females annually throughout the late 1970s to mid-1980s (Seminoff et al. 2015).

There is little available information on genetic diversity within the North Indian DPS, as mitochondrial DNA studies have only been completed on the Saudi Arabian stock, which was distinct from other rookeries in the Indian Ocean. Population sub-structuring within the DPS is likely, based on the broad spatial distribution of the DPS, but is unconfirmed (Seminoff et al. 2015).

The green turtle has a circumglobal distribution, occurring throughout nearshore tropical, sub-tropical and, to a lesser extent, temperate waters (Seminoff et al. 2015). Green turtles from the North Indian DPS are found along the eastern coast of Africa from Somalia north to the Red Sea. They are also found in the Gulf of Aden, the Persian Gulf, the Gulf of Oman and along the coast of India to Sri Lanka. Major nesting sites are found on the Arabian Peninsula to the Pakistani-Indian border.

Many nesting sites worldwide suffer from a lack of consistent, standardized monitoring, making it difficult to characterize population growth rates for a DPS.

Vocalization and Hearing

Sea turtles are low frequency hearing specialists, typically hearing frequencies from 30 Hz to 2 kHz, with a range of maximum sensitivity between 100 to 800 Hz (Ridgway et al. 1969; Lenhardt 1994; Bartol et al. 1999b; Lenhardt 2002; Moein Bartol and Ketten 2006). Piniak et al. (2012) found green turtle juveniles capable of hearing underwater sounds at frequencies of 50 Hz to 1,600 kHz (maximum sensitivity at 200 to 400 Hz). Hearing below 80 Hz is less sensitive but still possible (Lenhardt 1994). Based upon auditory brainstem responses green turtles have been measured to hear in the 50 Hz to 1.6 kHz range (Dow et al. 2008), with greatest response at 300 Hz (Yudhana et al. 2010); a value verified by Moein Bartol and Ketten (2006). Other studies have found greatest sensitivities are 200 to 400 Hz for the green turtle with a range of 100 to 500 Hz (Ridgway et al. 1969; Moein Bartol and Ketten 2006) and around 250 Hz or below for juveniles (Bartol et al. 1999b). However, Dow et al. (2008) found best sensitivity between 50 and 400 Hz.

These hearing sensitivities are similar to those reported for two terrestrial species: pond and wood turtles. Pond turtles respond best to sounds between 200 to 700 Hz, with slow declines below 100 Hz and rapid declines above 700 Hz, and almost no sensitivity above 3 kHz (Wever and Vernon 1956). Wood turtles are sensitive up to about 500 Hz, followed by a rapid decline above 1 kHz and almost no responses beyond 3 to 4 kHz (Patterson 1966).

Status

Once abundant in tropical and sub-tropical waters, green turtles worldwide exist at a fraction of their historical abundance, as a result of over-exploitation. Globally, egg harvest, the harvest of females on nesting beaches and directed hunting of sea turtles in foraging areas remain the three greatest threats to their recovery. In addition, bycatch in drift-net, long-line, set-net, pound-net, and trawl fisheries kill thousands of green turtles annually. Increasing coastal development (including beach erosion and re-nourishment, construction and artificial lighting) threatens nesting success and hatchling survival. On a regional scale, the different DPSs experience these threats as well, to varying degrees. Differing levels of abundance combined with different intensities of threats and effectiveness of regional regulatory mechanisms make each DPS uniquely susceptible to future perturbations.

Historically, egg harvest and capture of green turtles for consumption was a cause for the decline of North Indian DPS. The practice is restricted, but still occurs in some regions. Incidental bycatch in fisheries remains a significant threat to the DPS, as do in-water vessel strikes, collisions with beach vehicles during nesting, pollution, and climate change. Conservation laws are in effect, but the effectiveness of these protections vary by country. The large robust nesting beaches in Yemen and Oman contribute to the low risk of extinction for the North Indian DPS.

Critical Habitat

Not critical habitat has been designated for the North Indian DPS of green turtle. NMFS cannot designate critical habitat in foreign waters.

Recovery Goals

NMFS has not prepared a Recovery Plan for the North Indian DPS of green turtle. In general, ESA-listed species which occur entirely outside U.S. jurisdiction are not likely to benefit from recovery plans (55 FR 24296).

6.15 Green Turtle - Central West Pacific Distinct Population Segment

The green turtle is globally distributed and commonly inhabits nearshore and inshore waters, occurring throughout tropical, sub-tropical and, to a lesser extent, temperate waters (Figure 18). The Central West Pacific DPS of green turtle is found in the Pacific Ocean near Papua New Guinea, and West Papua (Figure 22).

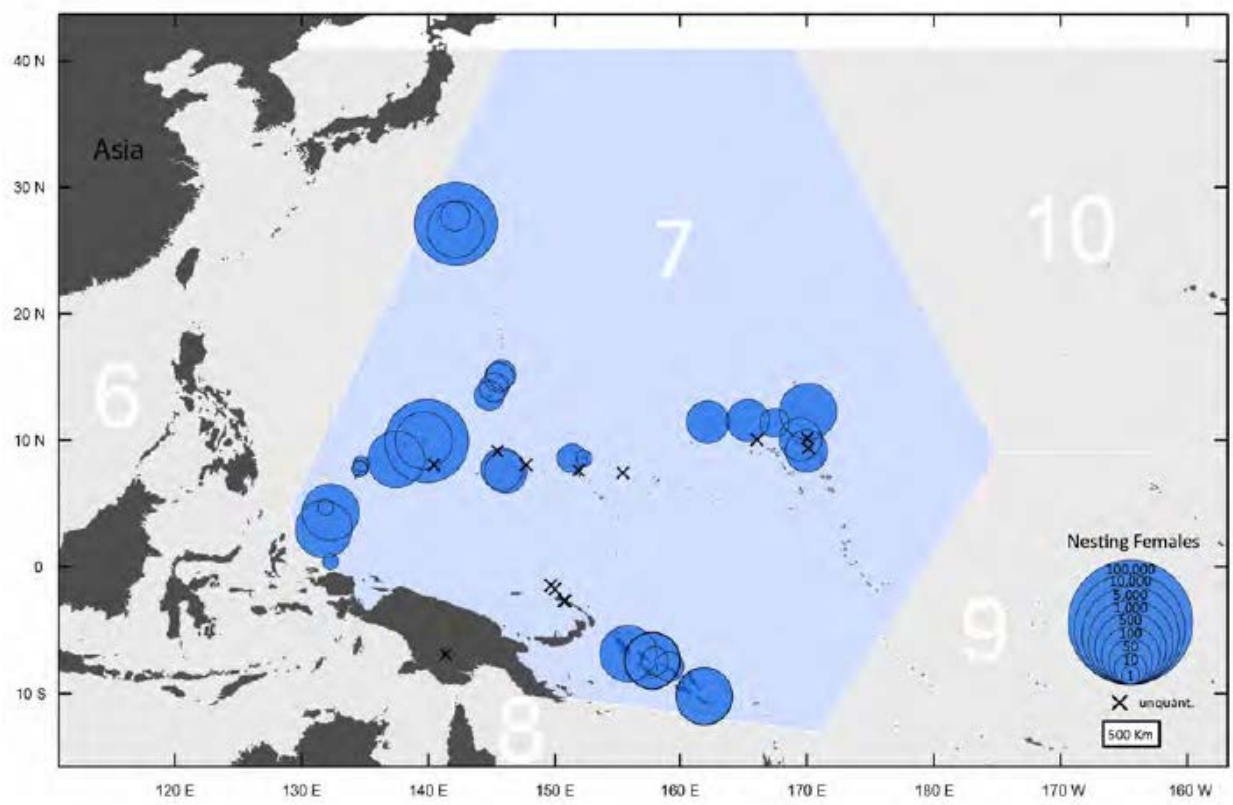

Figure 22. Geographic range of the Central West Pacific distinct population segment of green turtle, with location and abundance of nesting females (Seminoff et al. 2015).

The green turtle is the largest of the hardshell sea turtles, growing to a weight of 158.8 kg (350 lb) and a straight carapace length of greater than 1 m (3.3 ft). The species was listed under the ESA on July 28, 1978 (43 FR 32800). The species was separated into two ESA-listing designations: endangered for breeding populations in Florida and the Pacific coast of Mexico and threatened in all other areas throughout its range. On April 6, 2016, NMFS listed eleven DPSs of green turtles as threatened or endangered under the ESA. The Central West Pacific DPS is ESA-listed as endangered.

We used information available in the 2007 Five Year Review (USFWS 2007) and 2015 Status Review (Seminoff et al. 2015) to summarize the life history, population dynamics, and status of the species as follows.

Life History

Age at first reproduction for females is 20 to 40 years. Green turtles lay an average of three nests per season with an average of 100 eggs per nest. The remigration interval (i.e., return to natal beaches) is two to five years. Nesting occurs primarily on beaches with intact dune structure, native vegetation, and appropriate incubation temperatures during summer months. After emerging from the nest, hatchlings swim to offshore areas and go through a post-hatchling

pelagic stage where they are believed to live for several years. During this life stage, green turtles feed close to the surface on a variety of marine algae and other life associated with drift lines and debris. Adult sea turtles exhibit site fidelity and migrate hundreds to thousands of kilometers from nesting beaches to foraging areas. Green turtles spend the majority of their lives in coastal foraging grounds, which include open coastlines and protected bays and lagoons. Adult green turtles feed primarily on seagrasses and algae, although they also eat jellyfish, sponges, and other invertebrate prey.

Population Dynamics

The following discussion of the species' population and its variance over time. This section includes abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the Central West Pacific DPS of green turtle.

The green turtle occupies the coastal waters of over 140 countries worldwide; nesting occurs in more than 80 countries. Worldwide, nesting data at 464 sites indicate that 563,826 to 564,464 females nest each year (Seminoff et al. 2015). The largest nesting site is in the Federated States of Micronesia, which has 22 percent of the nesting females for the Central West Pacific DPS (Seminoff et al. 2015).

There are no estimates of population growth for the Central West Pacific DPS. Long-term nesting data is lacking for many of the nesting sites in the Central West Pacific DPS, making it difficult to assess population trends. The only site which has long-term data available – Chichijima, Japan – shows a positive trend in population growth (Seminoff et al. 2015).

The Central West Pacific DPS is made up of insular rookeries separated by broad geographic distances. Rookeries that are more than 1,000 km (540 nmi) apart are significantly differentiated, while rookeries 500 km (270 nmi) apart not. Mitochondrial DNA analyses suggest that there are at least seven independent stocks in the region (Dutton et al. 2014).

The green turtle has a circumglobal distribution, occurring throughout nearshore tropical, sub-tropical and, to a lesser extent, temperate waters (Seminoff et al. 2015). The Central West Pacific DPS is composed of nesting assemblages in the Federated States of Micronesia, the Japanese islands of Chichijima and Hahajima, the Marshall Islands, and Palau. Green turtles in the DPS are found throughout the western Pacific Ocean, in Indonesia, the Philippines, the Marshall Islands, and Papua New Guinea.

Many nesting sites worldwide suffer from a lack of consistent, standardized monitoring, making it difficult to characterize population growth rates for a DPS.

Vocalization and Hearing

Sea turtles are low frequency hearing specialists, typically hearing frequencies from 30 Hz to 2 kHz, with a range of maximum sensitivity between 100 to 800 Hz (Ridgway et al. 1969; Lenhardt 1994; Bartol et al. 1999b; Lenhardt 2002; Moein Bartol and Ketten 2006). Piniak et al. (2012) found green turtle juveniles capable of hearing underwater sounds at frequencies of 50 Hz

to 1,600 kHz (maximum sensitivity at 200 to 400 Hz). Hearing below 80 Hz is less sensitive but still possible (Lenhardt 1994). Based upon auditory brainstem responses green turtles have been measured to hear in the 50 Hz to 1.6 kHz range (Dow et al. 2008), with greatest response at 300 Hz (Yudhana et al. 2010); a value verified by Moein Bartol and Ketten (2006). Other studies have found greatest sensitivities are 200 to 400 Hz for the green turtle with a range of 100 to 500 Hz (Ridgway et al. 1969; Moein Bartol and Ketten 2006) and around 250 Hz or below for juveniles (Bartol et al. 1999b). However, Dow et al. (2008) found best sensitivity between 50 and 400 Hz.

These hearing sensitivities are similar to those reported for two terrestrial species: pond and wood turtles. Pond turtles respond best to sounds between 200 to 700 Hz, with slow declines below 100 Hz and rapid declines above 700 Hz, and almost no sensitivity above 3 kHz (Wever and Vernon 1956). Wood turtles are sensitive up to about 500 Hz, followed by a rapid decline above 1 kHz and almost no responses beyond 3 to 4 kHz (Patterson 1966).

Status

Once abundant in tropical and sub-tropical waters, green turtles worldwide exist at a fraction of their historical abundance, as a result of over-exploitation. Globally, egg harvest, the harvest of females on nesting beaches and directed hunting of sea turtles in foraging areas remain the three greatest threats to their recovery. In addition, bycatch in drift-net, long-line, set-net, pound-net, and trawl fisheries kill thousands of green turtles annually. Increasing coastal development (including beach erosion and re-nourishment, construction and artificial lighting) threatens nesting success and hatchling survival. On a regional scale, the different DPSs experience these threats as well, to varying degrees. Differing levels of abundance combined with different intensities of threats and effectiveness of regional regulatory mechanisms make each DPS uniquely susceptible to future perturbations.

The Central West Pacific DPS is impacted by incidental bycatch in fishing gear, predation of eggs by ghost crabs and rats, and directed harvest eggs and nesting females for human consumption. Historically, intentional harvest of eggs from nesting beaches was one of the principal causes for decline, and this practice continues today in many locations. The Central West Pacific DPS has a small number of nesting females and a widespread geographic range. These factors, coupled with the threats facing the Central West Pacific DPS and the unknown status of many nesting sites makes the Central West Pacific DPS vulnerable to future perturbations.

Critical Habitat

No critical habitat has been designated for the Central West Pacific DPS of green turtle. NMFS cannot designate critical habitat in foreign waters.

Recovery Goals

NMFS has not prepared a Recovery Plan for the Central West Pacific DPS green turtle. In general, ESA-listed species which occur entirely outside U.S. jurisdiction are not likely to benefit from recovery plans (55 FR 24296).

6.16 Hawksbill Turtle

The hawksbill turtle has a circumglobal distribution throughout tropical and, to a lesser extent, sub-tropical oceans (Figure 23).

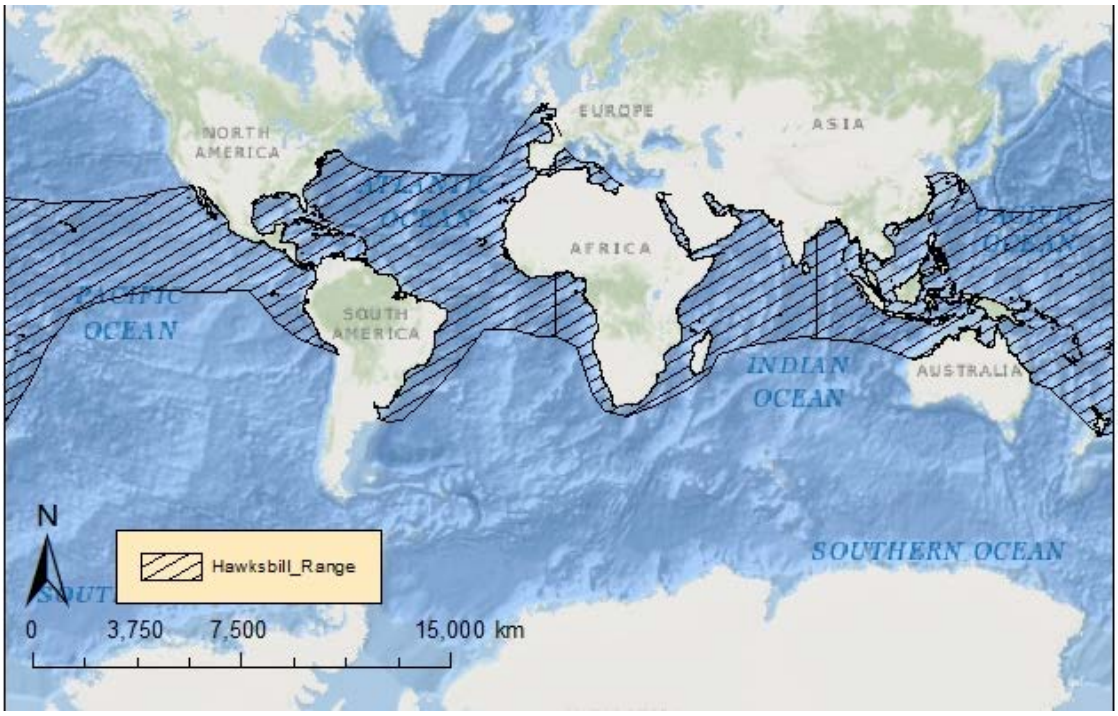

Figure 23. Map identifying the range of the endangered hawksbill turtle.

The hawksbill turtle has a sharp, curved, beak-like mouth and a "tortoiseshell" pattern on its carapace, with radiating streaks of brown, black, and amber. The species was first listed under the Endangered Species Conservation Act and has been listed as endangered under the ESA since 1973 (Table 12). We used information available in the five year reviews (NMFS and USFWS 2007b; NMFS 2013c) to summarize the life history, population dynamics and status of the species, as follows.

Life History

Hawksbill turtles reach sexual maturity at twenty to forty years of age. Females return to their natal beaches every two to five years to nest and nest an average of three to five times per season. Clutch sizes are large (up to 250 eggs). Sex determination is temperature dependent, with warmer incubation producing more females. Hatchlings migrate to and remain in pelagic habitats until they reach approximately twenty two to twenty five centimeters in straight carapace length. As juveniles, they take up residency in coastal waters to forage and grow. As adults, hawksbills

use their sharp beak-like mouths to feed on sponges and corals. Hawksbill turtles are highly migratory and use a wide range of habitats during their lifetimes (Musick and Limpus 1997; Plotkin 2003). Satellite tagged sea turtles have shown significant variation in movement and migration patterns. Distance traveled between nesting and foraging ranges from a few hundred to a few thousand kilometers (Miller et al. 1998; Horrocks et al. 2001).

Population Dynamics

The following is a discussion of the species' population and its variance over time. This section includes: abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the hawksbill turtle.

Surveys at 88 nesting sites worldwide indicate that 22,004 to 29,035 females nest annually (NMFS 2013c). In general, hawksbill turtles are doing better in the Atlantic and Indian Ocean than in the Pacific Ocean, where despite greater overall abundance, a greater proportion of the nesting sites are declining.

From 1980 through 2003, the number of nests at three primary nesting beaches (Rancho Nuevo, Tepehaujes, and Playa Dos) increased 15 percent annually (Heppell et al. 2005); however, due to recent declines in nest counts, decreased survival at other life stages, and updated population modeling, this rate is not expected to continue (NMFS 2013c).

Populations are distinguished generally by ocean basin and more specifically by nesting location. Our understanding of population structure is relatively poor. Genetic analysis of hawksbill turtles foraging off the Cape Verde Islands identified three closely-related haplotypes in a large majority of individuals sampled that did not match those of any known nesting population in the western Atlantic, where the vast majority of nesting has been documented (McClellan et al. 2010; Monzon-Arguello et al. 2010). Hawksbill turtles in the Caribbean Sea seem to have dispersed into separate populations (rookeries) after a bottleneck roughly 100,000 to 300,000 years ago (Leroux et al. 2012).

The hawksbill turtle has a circumglobal distribution throughout tropical and, to a lesser extent, sub-tropical waters of the Atlantic, Indian, and Pacific Oceans. In their oceanic phase, juvenile hawksbill turtles can be found in *Sargassum* mats; post-oceanic hawksbill turtles may occupy a range of habitats that include coral reefs or other hard-bottom habitats, sea grass, algal beds, mangrove bays and creeks (Musick and Limpus 1997; Bjorndal and Bolten 2010).

Vocalization and Hearing

Sea turtles are low frequency hearing specialists, typically hearing frequencies from 30 Hz to 2 kHz, with a range of maximum sensitivity between 100 to 800 Hz (Ridgway et al. 1969; Lenhardt 1994; Bartol et al. 1999b; Lenhardt 2002; Moein Bartol and Ketten 2006). Piniak et al. (2012) found hawksbill turtle hatchlings capable of hearing underwater sounds at frequencies of between 50 Hz to 1.6 kHz (maximum sensitivity at 200 to 400 Hz).

These hearing sensitivities are similar to those reported for two terrestrial species: pond and wood turtles. Pond turtles respond best to sounds between 200 to 700 Hz, with slow declines below 100 Hz and rapid declines above 700 Hz, and almost no sensitivity above 3 kHz (Wever and Vernon 1956). Wood turtles are sensitive up to about 500 Hz, followed by a rapid decline above 1 kHz and almost no responses beyond 3 or 4 kHz (Patterson 1966)

Status

Long-term data on hawksbill turtle indicate that 63 sites have declined over the past 20 to 100 hundred years (historic trends are unknown for the remaining 25 sites). Recently 28 sites (68 percent) have experienced nesting declines, ten have experienced increases, three have remained stable, and 47 have unknown trends. The greatest threats to hawksbill turtles are overharvesting of sea turtles and eggs, degradation of nesting habitat, and fisheries interactions. Adult hawksbill turtles are harvested for their meat and carapace, which is sold as tortoiseshell. Eggs are taken at high levels, especially in Southeast Asia where collection approaches 100 percent in some areas. In addition, lights on or adjacent to nesting beaches are often fatal to emerging hatchlings and alters the behavior of nesting adults. The species' resilience to additional perturbation is low.

Critical Habitat

On September 2, 1998, NMFS established critical habitat for hawksbill turtles around Mona and Monito Islands, Puerto Rico (Figure 24). Aspects of these areas that are important for hawksbill turtle survival and recovery include important natal development habitat, refuge from predation, shelter between foraging periods, and food for hawksbill turtle prey.

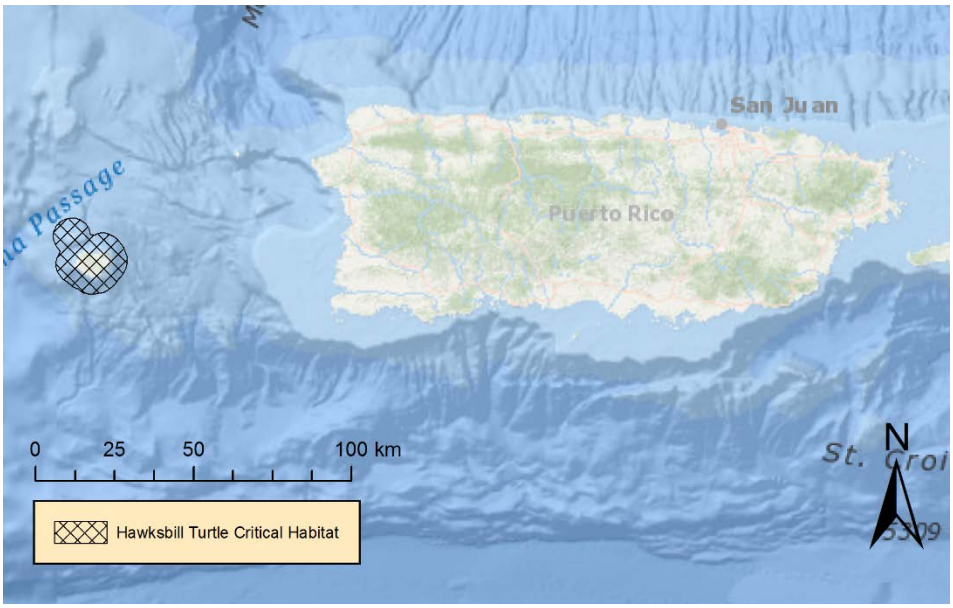

Figure 24. Map depicting hawksbill turtle designated critical habitat.

Recovery Goals

See the 1992 and 1998 Recovery Plans for the U.S. Caribbean, Atlantic, and Gulf of Mexico; and U.S. Pacific populations of hawksbill turtles, respectively, for complete downlisting/delisting criteria for each of their respective recovery goals. The following items were the top recovery actions identified to support in the Recovery Plans:

1. Identify important nesting beaches.
2. Ensure long-term protection and management of important nesting beaches.
3. Protect and manage nesting habitat; prevent the degradation of nesting habitat caused by seawalls, revetments, sand bags, other erosion-control measures, jetties, and breakwaters.
4. Identify important marine habitats; protect and manage populations in marine habitat.
5. Protect and manage marine habitat; prevent the degradation or destruction of important (marine) habitats caused by upland and coastal erosion.
6. Prevent the degradation of reef habitat caused by sewage and other pollutants.
7. Monitor nesting activity on important nesting beaches with standardized index surveys.
8. Evaluate nest success and implement appropriate nest-protection on important nesting beaches.
9. Ensure that law-enforcement activities prevent the illegal exploitation and harassment of sea turtles and increase law-enforcement efforts to reduce illegal exploitation.
10. Determine nesting beach origins for juveniles and sub-adult populations.

6.17 Leatherback Turtle

The leatherback turtle is unique among sea turtles for its large size, wide distribution (due to thermoregulatory systems and behavior), and lack of a hard, bony carapace. It ranges from tropical to sub-polar latitudes, worldwide (Figure 25).

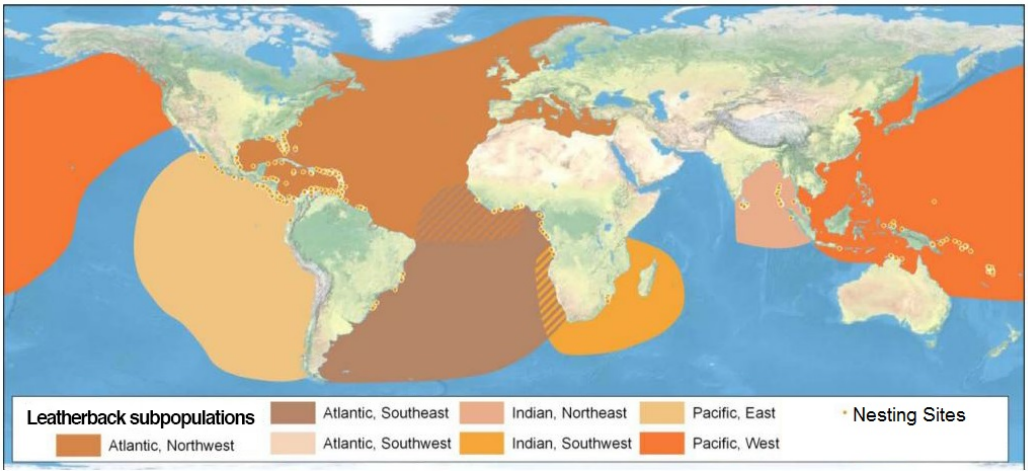

Figure 25. Map identifying the range of endangered leatherback turtle (adapted from (Wallace et al. 2013)).

Leatherback turtles are the largest living sea turtle, reaching lengths of 1.8 m (6 ft) long, and weighing up to 907.2 kg (2,000 lb). Leatherback turtles have a distinct black leathery skin

covering their carapace with pinkish white skin on their belly. The species was first listed under the Endangered Species Conservation Act and has been listed as endangered under the ESA since 1973 (Table 12).

We used information available in the five year review (NMFS 2013d) and critical habitat designation to summarize the life history, population dynamics, and status of the species as follows.

Life History

Age at maturity has been difficult to ascertain, with estimates ranging from five to 29 years (Spotila et al. 1996; Avens et al. 2009). Females lay up to seven clutches per season, with more than 65 eggs per clutch and eggs weighing greater than 80 grams (Reina et al. 2002; Wallace et al. 2007). The number of leatherback turtle hatchings that make it out of the nest on the beach (i.e., emergent success) is approximately 50 percent worldwide (Eckert et al. 2012). Females nest every one to seven years. Natal homing, at least within an ocean basin, results in reproductive isolation between five broad geographic regions: eastern and western Pacific, eastern and western Atlantic, and Indian Ocean. Leatherback turtles migrate long, transoceanic distances between their tropical nesting beaches and the highly productive temperate waters where they forage, primarily on jellyfish and tunicates. These gelatinous prey are relatively nutrient-poor, such that leatherback turtles must consume large quantities to support their body weight. Leatherback turtles weigh about 33 percent more on their foraging grounds than at nesting, indicating that they probably catabolize fat reserves to fuel migration and subsequent reproduction (James et al. 2005; Wallace et al. 2006). Sea turtles must meet an energy threshold before returning to nesting beaches. Therefore, their remigration intervals (the time between nesting) are dependent upon foraging success and duration (Hays 2000; Price et al. 2004).

Population Dynamics

The following is a discussion of the species' population and its variance over time. This section includes abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the leatherback turtle.

Leatherback turtles are globally distributed, with nesting beaches in the Pacific, Indian, and Atlantic Oceans. Detailed population structure is unknown, but is likely dependent upon nesting beach location. Based on estimates calculated from nest count data, there are between 34,000 and 94,000 adult leatherback turtles in the North Atlantic Ocean (TEWG 2007). In contrast, leatherback turtle populations in the Pacific Ocean are much lower. Overall, Pacific populations have declines from an estimated 81,000 individuals to less than 3,000 total adults and sub-adults (Spotila et al. 2000). Population abundance in the Indian Ocean is difficult to assess due to lack of data and inconsistent reporting. Available data from southern Mozambique show that approximately ten females nest per year from 1994 through 2004, and about 296 nests per year counted in South Africa (NMFS 2013d).

Population growth rates for leatherback turtles vary by ocean basin. Counts of leatherback turtles at nesting beaches in the western Pacific indicate that the sub-population has been declining at a rate of almost six percent per year since 1984 (Tapilatu et al. 2013). Leatherback turtle sub-populations in the Atlantic Ocean, however, are showing signs of improvement. Nesting females in South Africa are increasing at an annual rate of four to 5.6 percent, and from nine to 13 percent in Florida and the U.S. Virgin Islands (TEWG 2007), believed to be a result of conservation efforts.

Analyses of mitochondrial DNA from leatherback turtles indicates a low level of genetic diversity, pointing to possible difficulties in the future if current population declines continue (Dutton et al. 1999). Further analysis of samples taken from individuals from rookeries in the Atlantic and Indian Oceans suggest that each of the rookeries represent demographically independent populations (NMFS 2013d).

Leatherback turtles are distributed in oceans throughout the world (Figure 25). Leatherback turtles occur through marine waters, from nearshore habitats to oceanic environments (Shoop and Kenney 1992). Movements are largely dependent upon reproductive and feeding cycles and the oceanographic features that concentrate prey, such as frontal systems, eddy features, current boundaries, and coastal retention areas (Benson et al. 2011).

Vocalization and Hearing

Sea turtles are low frequency hearing specialists, typically hearing frequencies from 30 Hz to 2 kHz, with a range of maximum sensitivity between 100 and 800 Hz (Ridgway et al. 1969; Lenhardt 1994; Bartol et al. 1999b; Lenhardt 2002; Moein Bartol and Ketten 2006). To date, only one study has investigated hearing of the leatherback turtle (Piniak 2012). Piniak (2012) measured hearing of hatchlings in water an in air, and observed reactions to low frequency sounds, with responses to stimuli occurring between 50 Hz and 1.6 kHz in air between 50 Hz and 1.2 kHz in water (lowest sensitivity recorded was 93 dB re: 1 µPa at 300 Hz).

These hearing sensitivities are similar to those reported for two terrestrial species: pond and wood turtles. Pond turtles respond best to sounds between 200 and 700 Hz, with slow declines below 100 Hz and rapid declines above 700 Hz, and almost no sensitivity above 3,000 Hz (Wever and Vernon 1956). Wood turtles are sensitive up to about 500 Hz, followed by a rapid decline above 1 kHz and almost no responses beyond 3 to 4 kHz (Patterson 1966).

Status

The leatherback turtle is an endangered species whose once large nesting populations have experienced steep declines in recent decades. The primary threats to leatherback turtles include fisheries bycatch, harvest of nesting females, and egg harvesting. Because of these threats, once large rookeries are now functionally extinct, and there have been range-wide reductions in population abundance. Other threats include loss of nesting habitat due to development, tourism, and sand extraction. Lights on or adjacent to nesting beaches alter nesting adult behavior and are often fatal to emerging hatchlings as they are drawn to light sources and away from the sea.

Plastic ingestion is common in leatherbacks and can block gastrointestinal tracts leading to death. Climate change may alter sex ratios (as temperature determines hatchling sex), range (through expansion of foraging habitat), and habitat (through the loss of nesting beaches, because of sea-level rise. The species' resilience to additional perturbation is low.

Critical Habitat

On March 23, 1979, leatherback critical habitat was identified adjacent to Sandy Point, St. Croix, Virgin Islands from the 183 m (600 ft) isobath to mean high tide level between 17° 42' 12" North and 65° 50' 00" West (Figure 26). This habitat is essential for nesting, which has been increasingly threatened since 1979, when tourism increased significantly, bringing nesting habitat and people into close and frequent proximity. The designated critical habitat is within the Sandy Point National Wildlife Refuge. Leatherback turtle nesting increased at an annual rate of thirteen percent from 1994 to 2001; this rate has slowed according to nesting data from 2001 to 2010 (NMFS 2013d).

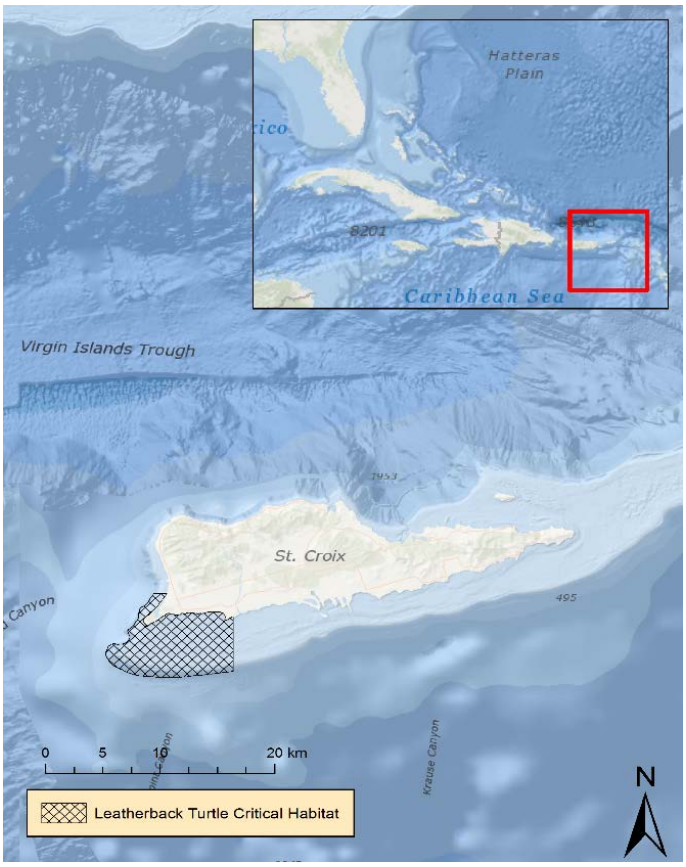

Figure 26. Map depicting leatherback turtle designated critical habitat in the United States Virgin Islands.

On January 20, 2012, NMFS issued a final rule to designate additional critical habitat for the leatherback turtle (50 CFR §226). This designation includes approximately 43,798 km^2 (12,769 nmi^2) stretching along the California coast from Point Arena to Point Arguello east of the 3,000

m (9,842 ft) depth contour; and 64,760 km^2 (18,881 nmi^2) stretching from Cape Flattery, Washington to Cape Blanco, Oregon east of the 2,000 m (6,562 ft) depth contour (Figure 27). The designated areas comprise approximately 108,558 km^2 (31,650 nmi^2) of marine habitat and include waters from the ocean surface down to a maximum depth of 80 m (262 ft). They were designated specifically because of the occurrence of prey species, primarily *scyphomedusae* of the order *Semaeostomeae* (i.e., jellyfish), of sufficient condition, distribution, diversity, abundance and density necessary to support individual as well as population growth, reproduction, and development of leatherbacks.

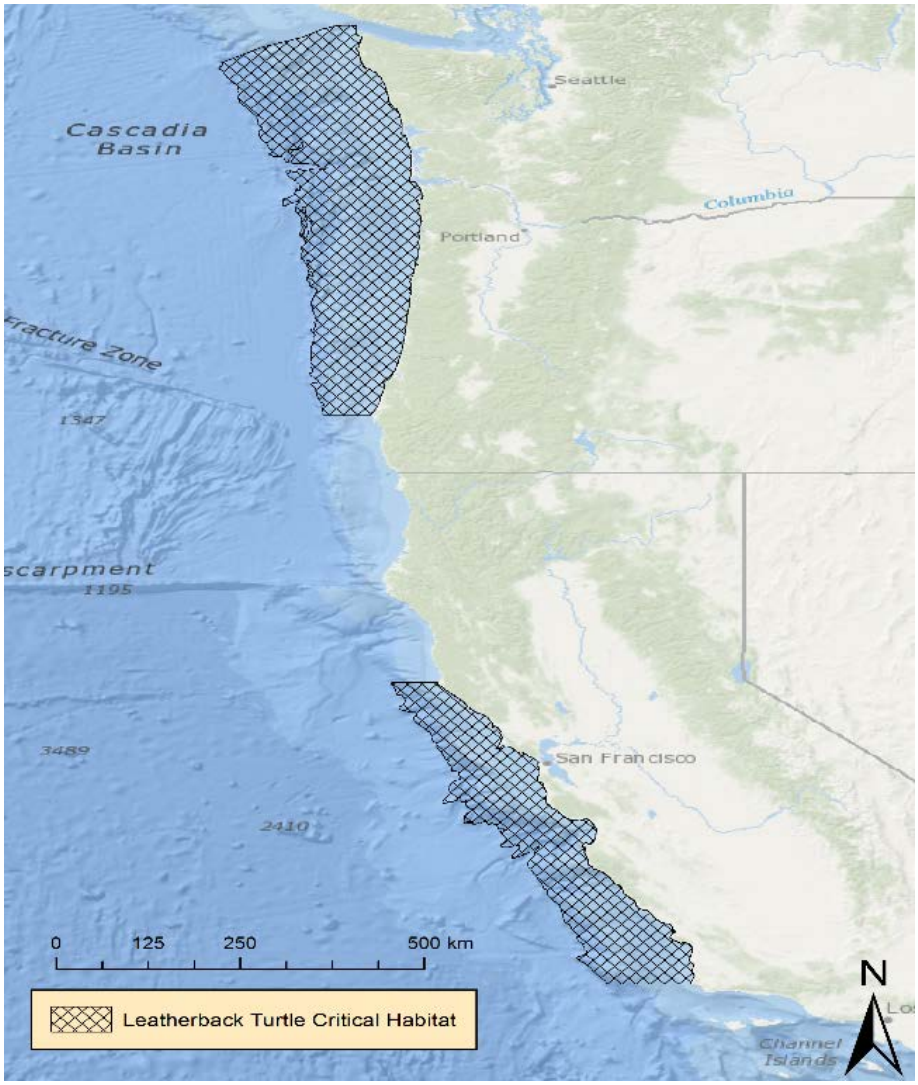

Figure 27. Map depicting leatherback turtle designated critical habitat along the United States Pacific Coast.

Recovery Goals

See the 1998 and 1991 Recovery Plans for the U.S. Pacific and U.S. Caribbean, Gulf of Mexico, and Atlantic leatherback turtles for complete downlisting/delisting criteria for each of their

respective recovery goals. The following items were the top five recovery actions identified to support in the Leatherback Five Year Action Plan:

1. Reduce fisheries interactions.
2. Improve nesting beach protection and increase reproductive output.
3. International cooperation.
4. Monitoring and research.
5. Public engagement.

6.18 Loggerhead Turtle – North Indian Ocean Distinct Population Segment

Loggerhead turtles are circumglobal and are found in the temperate and tropical regions of the Pacific, Indian, and Atlantic Oceans. North Indian Ocean DPS of loggerhead turtles are found in the northern Indian Ocean, along the east coast of Africa, the coasts of Yemen, Oman, Iran, Pakistan, India, and Southeast Asia (Figure 28).

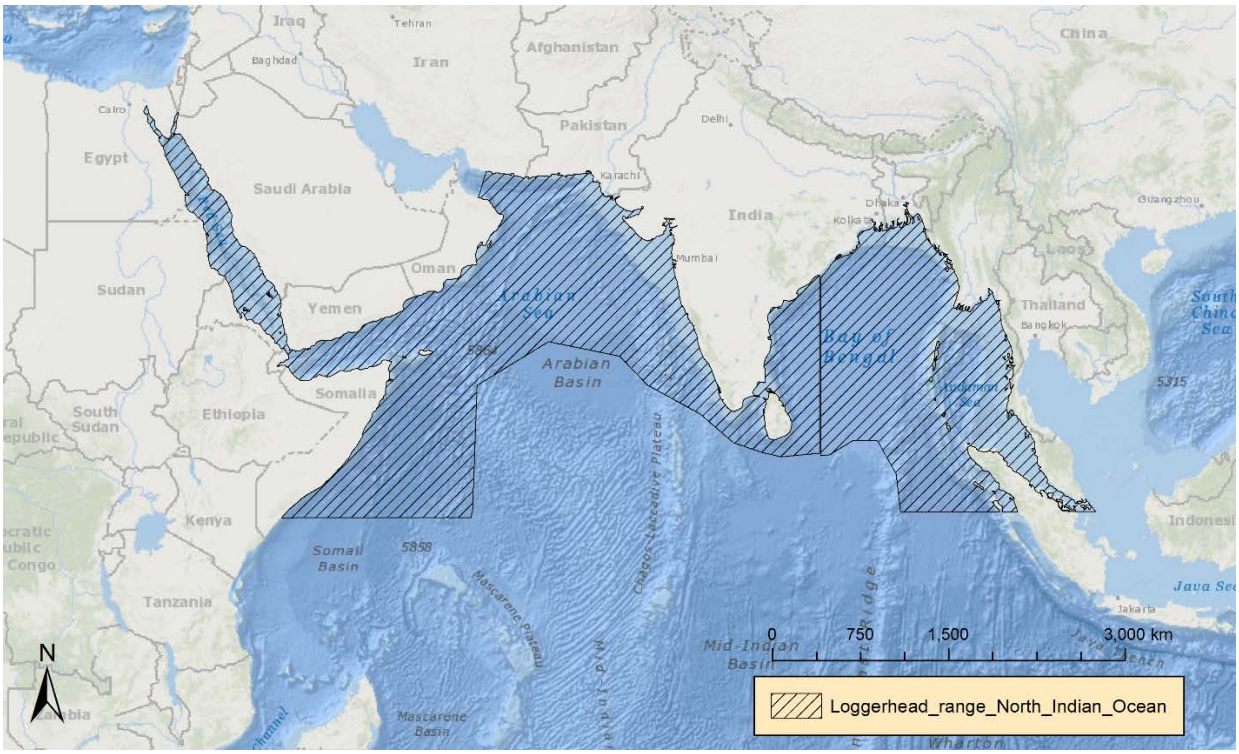

Figure 28. Map identifying the range of the North Indian Ocean distinct population segment of loggerhead turtle.

The loggerhead turtle is distinguished from other sea turtles by it reddish-brown carapace, large head, and powerful jaws. The species was first listed as threatened under the ESA in 1978 (43 FR 32800). On September 22, 2011, the NMFS designated nine DPSs of loggerhead turtles, with the North Indian Ocean DPS listed as endangered (Table 12).

We used information available in the 2009 Status Review (Conant et al. 2009) and the final ESA-listing rule to summarize the life history, population dynamics, and status of the species, as follows.

Life History

Mean age at first reproduction for female loggerhead turtles is 30 years. Females lay an average of three clutches per season. The annual average clutch size is 112 eggs per nest. The average remigration interval is 2.7 years. Nesting occurs on beaches, where warm, humid sand temperatures incubate the eggs. Temperature determines the sex of the sea turtle during the middle of the incubation period. Sea turtles spend the post-hatchling stage in pelagic waters. The juvenile stage is spent first in the oceanic zone and later in the neritic zone (i.e., coastal waters). Coastal waters provide important foraging habitat, inter-nesting habitat, and migratory habitat for adult loggerhead turtles.

Population Dynamics

The following is a discussion of the species' population and its variance over time. This section includes abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the North Indian Ocean DPS of loggerhead turtle.

There is a general agreement that the number of nesting females provides a useful index of the species' population size and stability at this life stage, even though there are no doubts about the ability to estimate the overall population size. Adult nesting females often account for less than one percent of total population numbers (Bjorndal et al. 2005). The global abundance of nesting female loggerhead turtles is estimated at 43,320 to 44,560.

Masirah Island in Oman is one of the largest loggerhead turtle nesting sites in the world, with an estimated 20,000 to 40,000 females nesting annually (Baldwin et al. 2003). Al-Halaiyat Island, also in Oman, supports about 3,000 nests annually (Salm 1991). The Arabian Sea coast of Oman is thought to host about 2,000 loggerhead nests every year (Salm et al. 1993). Sri Lanka hosts a small number of nesting females each year, but there is no evidence that the island was ever a major nesting area (Dodd Jr. 1988; Kapurusinghe 2006). In Yemen, between 50 and 100 females nest on the island of Socotra (Pilcher and Saad 2000). There are some accounts of loggerhead turtles nesting in Myanmar, but these reports are not considered reliable because the loggerhead turtles might be misidentified as olive ridley turtles (Thorbjarnarson et al. 2000).

There was not sufficient time series nesting data to calculate population growth rates for the North Indian Ocean DPS in the 2009 status review (Conant et al. 2009). All loggerhead turtles from Oman express a unique haplotype not found in Atlantic rookeries (Shamblin et al. 2014).

Loggerhead turtles are circumglobal, occurring throughout the temperate and tropical regions of the Pacific, Indian, and Atlantic Oceans, returning to their natal region for mating and nesting. Adults and sub-adults occupy nearshore habitat. While in their oceanic phase, loggerhead turtles undergo long migrations using ocean currents. Individuals from multiple nesting colonies can be

found on a single feeding ground. The Masirah Island, Oman, haplotype was present in foraging aggregations in the South Atlantic Ocean, indicating that loggerhead turtles from the North Indian Ocean DPS may use major surface currents to migrate to a different ocean basin to forage (Shamblin et al. 2014).

Vocalization and Hearing

Sea turtles are low frequency hearing specialists, typically hearing frequencies from 30 Hz to 2 kHz, with a range of maximum sensitivity between 100 and 800 Hz (Ridgway et al. 1969; Lenhardt 1994; Bartol et al. 1999b; Lenhardt 2002; Moein Bartol and Ketten 2006). Hearing below 80 Hz is less sensitive but still possible (Lenhardt 1994). Bartol et al. (1999b) reported effective hearing range for juvenile loggerhead turtles is from at least 250 to 750 Hz. Both yearling and two-year old loggerhead turtles had the lowest hearing threshold at 500 Hz (yearling: about 81 dB re: 1 µPa and two-year olds: about 86 dB re: 1 µPa), with threshold increasing rapidly above and below that frequency (Moein Bartol and Ketten 2006). Underwater tones elicited behavioral responses to frequencies between 50 and 800 Hz and auditory evoked potential responses between 100 and 1,131 Hz in one adult loggerhead turtle (Martin et al. 2012). The lowest threshold recorded in this study was 98 dB re: 1 µPa at 100 Hz. Lavender et al. (2014) found post-hatchling loggerhead turtles responded to sounds in the range of 50 to 800 Hz while juveniles responded to sounds in the range of 50 Hz to 1 kHz. Post-hatchlings had the greatest sensitivity to sounds at 200 Hz while juveniles had the greatest sensitivity at 800 Hz (Lavender et al. 2014).

These hearing sensitivities are similar to those reported for two terrestrial species: pond and wood turtles. Pond turtles respond best to sounds between 200 and 700 Hz, with slow declines below 100 Hz and rapid declines above 700 Hz, and almost no sensitivity above 3 kHz (Wever and Vernon 1956). Wood turtles are sensitive up to about 500 Hz, followed by a rapid decline above 1 kHz and almost no responds beyond 3 or 4 kHz (Patterson 1966).

Status

Although there is no nesting beach data available for the North Indian Ocean DPS of loggerhead turtle, the threat matrix indicates a likely decline in the population in the foreseeable future. This predicted decline is driven by mortality in commercial and artisanal fisheries and threats to nesting beaches (Conant et al. 2009).

Critical Habitat

No critical habitat has been designated for the North Indian Ocean DPS of loggerhead turtle. NMFS cannot designate critical habitat in foreign waters.

Recovery Goals

NMFS has not prepared a Recovery Plan for the North Indian Ocean DPS of loggerhead turtle. In general, ESA-listed species which occur entirely outside U.S. jurisdiction are not likely to benefit from recovery plans (55 FR 24296).

6.19 Loggerhead Turtle – North Pacific Ocean Distinct Population Segment

Loggerhead turtles are circumglobal and are found in the temperate and tropical regions of the Pacific, Indian, and Atlantic Oceans. North Pacific Ocean DPS of loggerhead turtles are found throughout the Pacific Ocean, north of the equator. Their range extends from the West Coast of North America to eastern Asia (Figure 29).

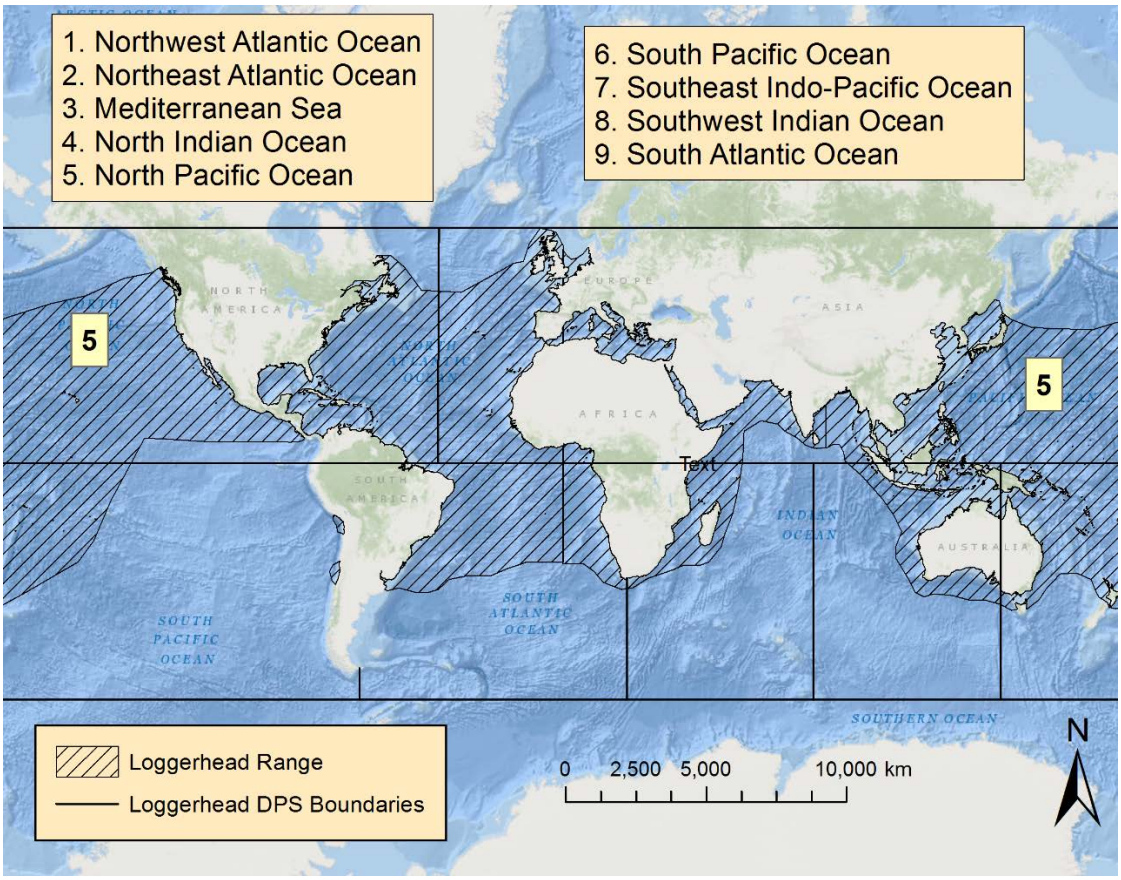

Figure 29. Map identifying the range of the North Pacific Ocean distinct population segment loggerhead turtle.

The loggerhead turtle is distinguished from other sea turtles by it reddish-brown carapace, large head, and powerful jaws. The species was first listed as threatened under the ESA in 1978 (43 FR 32800). On September 22, 2011, the NMFS designated nine DPSs of loggerhead turtles, with the North Pacific Ocean DPS listed as endangered.

We used information available in the 2009 Status Review (Conant et al. 2009) and the final ESA-listing rule to summarize the life history, population dynamics, and status of the species, as follows.

Life History

Mean age at first reproduction for female loggerhead turtles is 30 years. Females lay an average of three clutches per season. The annual average clutch size is 112 eggs per nest. The average

remigration interval is 2.7 years. Nesting occurs on beaches, where warm, humid sand temperatures incubate the eggs. Temperature determines the sex of the sea turtle during the middle of the incubation period. Sea turtles spend the post-hatchling stage in pelagic waters. The juvenile stage is spent first in the oceanic zone and later in the neritic zone (i.e., coastal waters). Coastal waters provide important foraging habitat, inter-nesting habitat, and migratory habitat for adult loggerhead turtles.

Population Dynamics

The following is a discussion of the species' population and its variance over time. This section includes abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the North Indian Ocean DPS of loggerhead turtle.

There is a general agreement that the number of nesting females provides a useful index of the species' population size and stability at this life stage, even though there are no doubts about the ability to estimate the overall population size. Adult nesting females often account for less than one percent of total population numbers (Bjorndal et al. 2005). The global abundance of nesting female loggerhead turtles is estimated at 43,320 to 44,560.

The North Pacific Ocean DPS of loggerhead turtle has a nesting population of about 2,300 nesting females (Matsuzawa 2011). Loggerhead turtles abundance on foraging grounds off the Pacific Coast of the Baja California Peninsula, Mexico, was estimated to be 43,226 individuals (Seminoff et al. 2014).

Overall, Gilman (2009) estimated that the number of loggerhead turtles nesting in the Pacific Ocean has declined by 80 percent in the past 20 years. There was a steep (50 to 90 percent) decline in the annual nesting population in Japan during the last half of the 20th century (Kamezaki et al. 2003). Since then, nesting has gradually increased, but is still considered to be depressed compared to historical numbers, and the population growth rate is negative (-0.032) (Conant et al. 2009).

Recent mitochondrial DNA analysis using longer sequences has revealed a more complex population sub-structure for the North Pacific Ocean DPS of loggerhead turtle. Previously, five haplotypes were present, and now, nine haplotypes have been identified in the North Pacific Ocean DPS. This evidence supports the designation of three management units in the North Pacific Ocean DPS: (1) the Ryuku management unit (Okinawa, Okinoerabu, and Amami), (2) Yakushima Island management unit, and (3) Mainland management unit (Bousou, Enshu-nada, Shikoku, Kii, and Eastern Kyushu) (Matsuzawa et al. 2016). Genetic analysis of loggerhead turtles captured on the feeding grounds of Sanriku, Japan, found only haplotypes present in Japanese rookeries (Nishizawa et al. 2014).

Loggerhead turtles are circumglobal, occurring throughout the temperate and tropical regions of the Pacific, Indian, and Atlantic Oceans, returning to their natal region for mating and nesting. Adults and sub-adults occupy nearshore habitat. While in their oceanic phase, loggerhead turtles

undergo long migrations using ocean currents. Individuals from multiple nesting colonies can be found on a single feeding ground.

Hatchlings from Japanese nesting beaches use the North Pacific Subtropical Gyre and the Kurishio Extension to migrate to foraging grounds. Two major juvenile foraging areas have been identified in the North Pacific Basin: Central North Pacific and off Mexico's Baja California Peninsula. Both of these feeding grounds are frequented by individuals from Japanese nesting beaches (Abecassis et al. 2013; Seminoff et al. 2014).

Vocalization and Hearing

Sea turtles are low frequency hearing specialists, typically hearing frequencies from 30 Hz to 2 kHz, with a range of maximum sensitivity between 100 and 800 Hz (Ridgway et al. 1969; Lenhardt 1994; Bartol et al. 1999b; Lenhardt 2002; Moein Bartol and Ketten 2006). Hearing below 80 Hz is less sensitive but still possible (Lenhardt 1994). Bartol et al. (1999b) reported effective hearing range for juvenile loggerhead turtles is from at least 250 to 750 Hz. Both yearling and two-year old loggerhead turtles had the lowest hearing threshold at 500 Hz (yearling: about 81 dB re: 1 µPa and two-year olds: about 86 dB re: 1 µPa), with threshold increasing rapidly above and below that frequency (Moein Bartol and Ketten 2006). Underwater tones elicited behavioral responses to frequencies between 50 and 800 Hz and auditory evoked potential responses between 100 and 1,131 Hz in one adult loggerhead turtle (Martin et al. 2012). The lowest threshold recorded in this study was 98 dB re: 1 µPa at 100 Hz. Lavender et al. (2014) found post-hatchling loggerhead turtles responded to sounds in the range of 50 to 800 Hz while juveniles responded to sounds in the range of 50 Hz to 1 kHz. Post-hatchlings had the greatest sensitivity to sounds at 200 Hz while juveniles had the greatest sensitivity at 800 Hz (Lavender et al. 2014).

These hearing sensitivities are similar to those reported for two terrestrial species: pond and wood turtles. Pond turtles respond best to sounds between 200 and 700 Hz, with slow declines below 100 Hz and rapid declines above 700 Hz, and almost no sensitivity above 3 kHz (Wever and Vernon 1956). Wood turtles are sensitive up to about 500 Hz, followed by a rapid decline above 1 kHz and almost no responds beyond 3 or 4 kHz (Patterson 1966).

Status

Neritic juveniles and adults in the North Pacific Ocean DPS of loggerhead turtle are at risk of mortality from coastal fisheries in Japan and Baja California, Mexico. Habitat degradation in the form of coastal development and armoring pose a threat to nesting females. Based on these threats and the relatively small population size, the Biological Review Team concluded that the North Pacific Ocean DPS of loggerhead turtle is currently at risk of extinction (Conant et al. 2009).

Critical Habitat

No critical habitat has been designated for the North Pacific Ocean DPS of loggerhead turtle.

Recovery Goals

NMFS has not prepared a Recovery Plan for the North Pacific Ocean DPS of loggerhead turtle.

6.20 Loggerhead Turtle – Southeast Indo-Pacific Ocean Distinct Population Segment

Loggerhead turtles are circumglobal and are found in the temperate and tropical regions of the Pacific, Indian, and Atlantic Oceans. South Indo-Pacific Ocean DPS of loggerhead turtles are found in the Indian Ocean, in the waters around Western Australia, Indonesia, and Papua New Guinea (Figure 30).

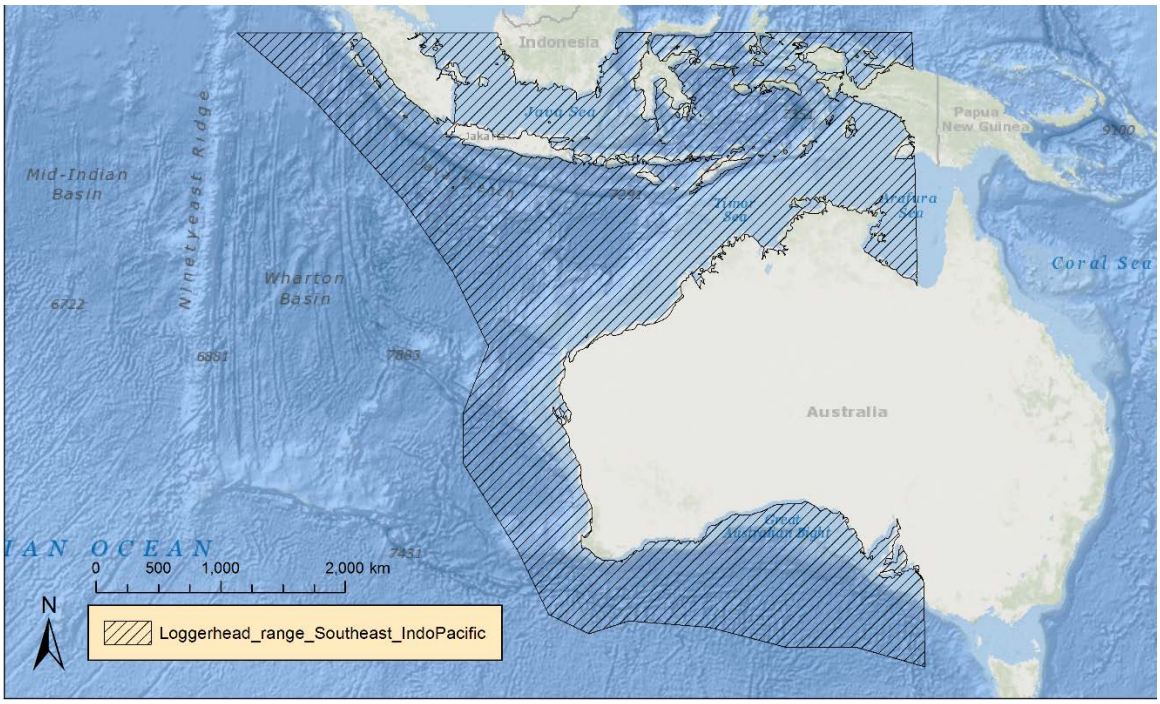

Figure 30. Map identifying the range of the Southeast Indo-Pacific Ocean distinct population segment of loggerhead turtle.

The loggerhead turtle is distinguished from other sea turtles by it reddish-brown carapace, large head, and powerful jaws. The species was first listed as threatened under the ESA in 1978 (43 FR 32800). On September 22, 2011, the NMFS designated nine DPSs of loggerhead turtles, with the Southeast Indo-Pacific Ocean DPS listed as threatened.

We used information available in the 2009 Status Review (Conant et al. 2009) and the final ESA-listing rule to summarize the life history, population dynamics, and status of the species, as follows.

Life History

Mean age at first reproduction for female loggerhead turtles is 30 years. Females lay an average of three clutches per season. The annual average clutch size is 112 eggs per nest. The average remigration interval is 2.7 years. Nesting occurs on beaches, where warm, humid sand

temperatures incubate the eggs. Temperature determines the sex of the sea turtle during the middle of the incubation period. Sea turtles spend the post-hatchling stage in pelagic waters. The juvenile stage is spent first in the oceanic zone and later in the neritic zone (i.e., coastal waters). Coastal waters provide important foraging habitat, inter-nesting habitat, and migratory habitat for adult loggerhead turtles.

Population Dynamics

The following is a discussion of the species' population and its variance over time. This section includes abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the Southeast Indo-Pacific Ocean DPS of loggerhead turtle.

There is a general agreement that the number of nesting females provides a useful index of the species' population size and stability at this life stage, even though there are no doubts about the ability to estimate the overall population size. Adult nesting females often account for less than one percent of total population numbers (Bjorndal et al. 2005). The global abundance of nesting female loggerhead turtles is estimated at 43,320 to 44,560.

Nesting for the Southeast Indo-Pacific Ocean DPS of loggerhead turtle is restricted to western Australia, with three main nesting beaches: Dirk Harog Island, Murion Island, and North West Cape (Baldwin et al. 2003). About 70 to 75 percent of females in the region nest at Dirk Hartog Island or about 800 to 1,500 females annually. The remainder nest at Murion Island (150 to 350 annually) and North West Cape (50 to 150 annually) (Baldwin et al. 2003). There was not sufficient time series nesting data to calculate population growth rates for the Southeast Indo-Pacific DPS in the 2009 status review (Conant et al. 2009).

Nesting for the Southeast Indo-Pacific DPS of loggerhead turtle occurs exclusively in western Australia, and mitochondrial DNA analysis has revealed high levels of genetic diversity, with nine haplotypes identified (Pacioni et al. 2012). Adult populations in the Southeast Indo-Pacific DPS are highly structured with no overlap among other adult loggerheads in the Indian Ocean basin (Conant et al. 2009).

Loggerhead turtles are circumglobal, occurring throughout the temperate and tropical regions of the Pacific, Indian, and Atlantic Oceans, returning to their natal region for mating and nesting. Adults and sub-adults occupy nearshore habitat. While in their oceanic phase, loggerhead turtles undergo long migrations using ocean currents. Individuals from multiple nesting colonies can be found on a single feeding ground.

There is some variation in dispersal patterns of loggerhead turtles of the Southeast Indo-Pacific Ocean DPS. Tagged adult males in Western Australia exhibited relatively small areas (186 km^2 [54.2 nmi^2]) within coastal foraging areas (Olson et al. 2012). Stable isotope data analysis indicates that loggerhead turtles in Shark Bay, Western Australia, show strong fidelity to particular foraging areas over many years (Thomson et al. 2012). The Western Australia haplotype was present in individuals in a Brazilian foraging aggregation in the South Atlantic

Ocean, indicating that loggerhead turtles from the Southwest Indian Ocean DPS may use major surface currents to migrate to a different ocean basin to forage (Shamblin et al. 2014).

Vocalization and Hearing

Sea turtles are low frequency hearing specialists, typically hearing frequencies from 30 Hz to 2 kHz, with a range of maximum sensitivity between 100 and 800 Hz (Ridgway et al. 1969; Lenhardt 1994; Bartol et al. 1999b; Lenhardt 2002; Moein Bartol and Ketten 2006). Hearing below 80 Hz is less sensitive but still possible (Lenhardt 1994). Bartol et al. (1999b) reported effective hearing range for juvenile loggerhead turtles is from at least 250 to 750 Hz. Both yearling and two-year old loggerhead turtles had the lowest hearing threshold at 500 Hz (yearling: about 81 dB re: 1 µPa and two-year olds: about 86 dB re: 1 µPa), with threshold increasing rapidly above and below that frequency (Moein Bartol and Ketten 2006). Underwater tones elicited behavioral responses to frequencies between 50 and 800 Hz and auditory evoked potential responses between 100 and 1,131 Hz in one adult loggerhead turtle (Martin et al. 2012). The lowest threshold recorded in this study was 98 dB re: 1 µPa at 100 Hz. Lavender et al. (2014) found post-hatchling loggerhead turtles responded to sounds in the range of 50 to 800 Hz while juveniles responded to sounds in the range of 50 Hz to 1 kHz. Post-hatchlings had the greatest sensitivity to sounds at 200 Hz while juveniles had the greatest sensitivity at 800 Hz (Lavender et al. 2014).

These hearing sensitivities are similar to those reported for two terrestrial species: pond and wood turtles. Pond turtles respond best to sounds between 200 and 700 Hz, with slow declines below 100 ha and rapid declines above 700 Hz, and almost no sensitivity above 3 kHz (Wever and Vernon 1956). Wood turtles are sensitive up to about 500 Hz, followed by a rapid decline above 1 kHz and almost no responds beyond 3 or 4 kHz (Patterson 1966).

Status

There was not adequate time series of nesting data for this Southeast Indo-Pacific DPS to evaluate extinction risk, so the Biological Review Team relied on modeling to determine the effects of threats to the Southeast Indo-Pacific DPS. The worst-case scenario deterministic model indicated that the Southeast Indo-Pacific Ocean DPS of loggerhead turtle is likely to substantially decline in the foreseeable future, mostly due to fisheries bycatch of juveniles and adults in the region (Conant et al. 2009).

Critical Habitat

No critical habitat has been designated for the Southeast Indo-Pacific Ocean DPS of loggerhead turtle. NMFS cannot designate critical habitat in foreign waters.

Recovery Goals

NMFS has not prepared a Recovery Plan for the Southeast Indo-Pacific Ocean DPS of loggerhead turtle. In general, ESA-listed species which occur entirely outside U.S. jurisdiction are not likely to benefit from recovery plans (55 FR 24296).

6.21 Olive Ridley Turtle

The olive ridley turtle is a small, mainly pelagic, sea turtle with circumtropical distribution (Figure 31).

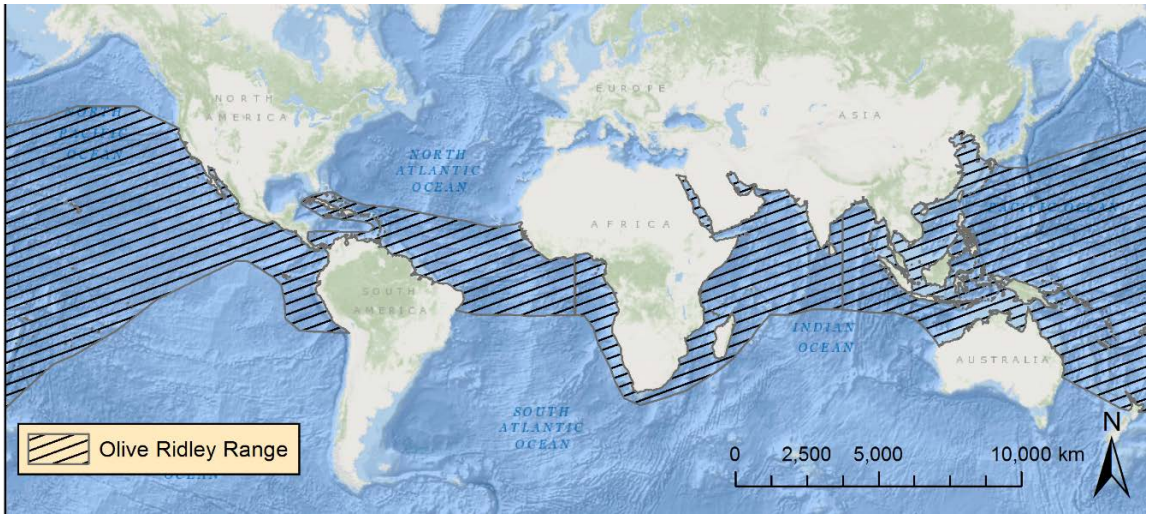

Figure 31. Map identifying the range of the olive ridley turtle.

Olive ridley turtles are olive or grayish-green in color, with a heart-shaped carapace. The species was listed under the ESA on July 28, 1978. The species was separated into two ESA-listing designations: endangered for breeding populations on the Pacific coast of Mexico, and threatened wherever found except where listed as endangered (i.e., in all other areas throughout its range).

We used information available in the five year review (NMFS and USFWS 2014) to summarize the life history, population dynamics, and status of the threatened olive ridley turtle, as follows.

Life History

Olive ridley turtle females mature at ten to 18 years of age. They lay an average of two clutches per season (three to six months in duration). The annual average clutch size is 100 to 110 eggs per nest. Olive ridley turtles commonly nest in successive years. Females nest in solitary or in arribadas, large aggregations coming ashore at the same time and location. The post-breeding behavior of olive ridley turtles in the eastern Pacific Ocean is unique in that they are nomadic, migrating across ocean basins. This contrasts with other sea turtle species, which typically migrate to a particular feeding ground after nesting. As adults, olive ridley turtles forage on crustaceans, fish, mollusks, and tunicates, primarily in pelagic habitats.

Population Dynamics

The following is a discussion of the species' population and its variance over time. This section includes: abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the endangered range-wide population of the olive ridley turtle and endangered Pacific coast of Mexico breeding population of the olive ridley turtle (NMFS and USFWS 2014).

Olive ridley turtles are thought to be the most abundant species of sea turtle, and can be found in the Atlantic, Indian, and Pacific Oceans. There is no global estimate of olive ridley turtle abundance, and we rely on nest counts and nesting females to estimate abundance in each of the ocean basins, described below. Shipboard transects along the Mexico and Central America coasts between 1992 and 2006 indicate an estimated 1,390,000 adults. There are six primary arribada nesting beaches in Mexico; the largest begin La Escobilla, with about one million nesting females annually. There are several monitored nesting beaches where solitary nesting occurs. At Nuevo Vallarta, about 4,900 nests are laid annually.

In the Western Atlantic Ocean, two arribada nesting beaches occur in Suriname and French Guiana. The Cayenne Peninsula in French Guiana hosts about 2,000 nests annually, while the Galibi Nature Reserve in Suriname had 335 nests in 1995. Solitary nesting also occurs elsewhere in Suriname, Guyana, and French Guiana; although no abundance estimates are available. In Sergipe, Brazil, solitary nesting amounted to about 2,600 nests in 2002 and 2003.

In the Eastern Atlantic Ocean, there are no arribada nesting beaches, but solitary nesting occurs in several countries along the western coast of Africa, from Gambia to Angola. For many countries, there are no abundance estimates available. For beaches with data available (Angola, the Republic of Congo, the Democratic Republic of Congo, Equatorial Guinea, and Guinea Bissau), nest counts are low, with most monitoring taking place for only a few years. The most abundant nesting beaches are Orango National Park in Guinea Bissau, which had between 170 and 620 nests from 1992 through 1994; and the Republic of Congo, which had between 300 and 600 nests annually from 2003 through 2010 (NMFS and USFWS 2014).

In the Indian Ocean, three arribada nesting beaches are found in India, amounting to 150,000 to 200,000 nesting females annually. Solitary nesting also occurs elsewhere in the region, in eastern Africa, Oman, India, Pakistan, and other Southeast Asian countries; for many, there are no estimates available. The largest recorded nesting beach is in Myanmar, when in 1999, 700 nests were counted (NMFS and USFWS 2014).

There are no known arribada nesting beaches in western Pacific Ocean; however, some solitary nesting occurs in Australia, Brunei, Malaysia, Indonesia, and Vietnam. Data are lacking for many sites. Terengganu, Malaysia had ten nests in 1998 and 1999. Alas Purwo, Indonesia, had 230 nests annually from 1993 through 1998.

In the eastern Pacific Ocean (excluding breeding populations in Mexico), there are arribada nesting beaches in Nicaragua, Costa Rica, and Panama. La Flor, Nicaragua had 521,440 effective nesting females in 2008 through 2009; Chacocente, Nicaragua had 27,947 nesting females over the same period (Gago et al. 2012). Two other arribada nesting beaches are in Nicaragua, Masachapa and Pochomil, but there are no abundance estimates available. Costa Rica hosts two major arribada nesting beaches, Ostional has between 3,564 and 476,550 sea turtles per arribada, and Nancite has between 256 and 41,149 sea turtles per arribada. Panama has one arribada nesting beach, with 8,768 sea turtles annually.

There are several solitary nesting beaches in the East Pacific Ocean (excluding breeding populations in Mexico); however, no abundance estimates are available for beaches in El Salvador, Honduras, Nicaragua, Costa Rica, Panama, Colombia, and Ecuador. On Hawaii Beach in Guatemala, 1,004 females were recorded in 2005 (NMFS and USFWS 2014).

Population growth rate and trend information for the threatened population of olive ridley turtles is difficult to discern owing to its range over a large geographic area, and a lack of consistent monitoring data in all nesting areas. Below, we present the any known population trend information for olive ridley turtles by ocean basin (NMFS and USFWS 2014).

Nesting at arribada beaches in French Guiana appears to be increasing, while in Suriname, nesting has declined by more than 90 percent since 1968. Solitary nesting also occurs elsewhere in Suriname, Guyana, and French Guiana; no trend data are available. Solitary nesting in Brazil appears to be increasing, with one hundred nests recorded in 1989 to 1990, to 2,606 in 2002 through 2003.

In the Eastern Atlantic Ocean, trend data is not available for most solitary nesting beaches. Nest counts in the Republic of Congo decreased from 600 nests in 2003 and 2004 to less than 300 in 2009 and 2010.

The three arribada nesting beaches in India – Gahirmatha, Rushikulya, and Devi River – are considered stable over three generations. There is no trend data available for several solitary nesting beaches in the Indian Ocean. However, even for the few beaches with short-term monitoring, the nest counts are believed to represent a decline from earlier years.

There are no arribada nesting beaches in the Western Pacific Ocean. Data are lacking for inconsistent for many solitary nesting beaches in the Western Pacific Ocean, so it is not possible to assess population trends for these sites. Nest counts at Alas Purwo, Indonesia, appear to be increasing, the nest count at Terengganu, Malaysia, is thought to be a decline from previous years.

Population trends at Nicaraguan arribada nesting beaches are unknown or stable (La Flor). Ostional, Costa Rica arribada nesting beach is increasing, while trends Nancite, Costa Rica, and Isla Canas, Panama, nesting beaches are declining. For most solitary nesting beaches in the East Pacific Ocean, population trends are unknown, except for Hawaii Beach, Guatemala, which is decreasing.

Based on the number of olive ridley turtles nesting in Mexico, populations appear to be increasing in one location (La Escobilla: from 50,000 nests in 1998 to more than 1,000,000 in 2000), decreasing at Chacahua, and stable at all others. At-sea estimates of olive ridley turtles off Mexico and Central America also support an increasing population trend.

Genetic studies have identified four main lineages for the olive ridley turtle: east India, Indo-Western Pacific, Atlantic, and the eastern Pacific. In the eastern Pacific Ocean, rookeries on the Pacific Coasts of Costa Rica and Mexico were not genetically distinct, and fine-scale population

structure was not found when solitary and arribada nesting beaches were examined. There was no population subdivision among olive ridley turtles along the east India coastline. Low levels of genetic diversity among Atlantic French Guinea and eastern Pacific Baja California nesting sites are attributed to a population collapse caused by past overharvest (NMFS and USFWS 2014).

Globally, olive ridley turtles can be found in tropical and sub-tropical waters in the Atlantic, Indian, and Pacific Oceans (Figure 31). The range of the endangered Pacific coast breeding population extends as far south as Peru and up to California. Olive ridley turtles of the Pacific coast breeding colonies nest on arribada beaches at Mismaloya, Ixtapilla, and La Escobilla, Mexico. Solitary nesting takes place all along the Pacific coast of Mexico. Major nesting arribada beaches are found in Nicaragua, Costa Rica, Panama, India, and Suriname.

Vocalization and Hearing

Sea turtles do not appear to use sound for communication, and there are no published recordings of olive ridley sea turtle vocalizations. There is not information on olive ridley turtle hearing. However, we assume that their hearing sensitivities will be similar to those of green, hawksbill, leatherback, and loggerhead turtles, whose best hearing sensitivity is in the low frequency range, with maximum sensitivity below 400 Hz and an upper hearing range not likely to exceed 2 kHz.

These hearing sensitivities are similar to those reported for two terrestrial species: pond and wood turtles. Pond turtles respond best to sounds between 200 and 700 Hz, with slow declines below 100 Hz and rapid declines above 700 Hz, and almost no sensitivity above 3,000 Hz (Wever and Vernon 1956). Wood turtles are sensitive up to about 500 Hz, followed by a rapid decline above 1 kHz and almost no responses beyond 3 to 4 kHz (Patterson 1966).

Status

It is likely that solitary nesting locations once hosted large arribadas; since the 1960s, populations have experienced declines in abundance of 50 to 80 percent. Many populations continue to decline. Olive ridley turtles continue to be harvested as eggs and adults, legally in some areas, and illegally in others. Incidental capture in fisheries is also a major threat. The olive ridley turtle is the most abundant sea turtle in the world; however, several populations are declining as a result of continued harvest and fisheries bycatch. The large population size of the range-wide population, however, allows some resilience to future perturbation.

In the first half of the 20th century, there was an estimated ten million olive ridley turtles nesting on the Pacific coast of Mexico. Olive ridley turtles became targeted in a fishery in Mexico and Ecuador, which severely depleted the population; there was an estimated 1,000,000 olive ridley turtles by 1969. Olive ridley turtle breeding populations on the Pacific coast of Mexico were listed as endangered in response to this severe population decline. Legal harvest of olive ridley turtles has been prohibited, although illegal harvest still occurs. The population is threatened by incidental capture in fisheries, exposure to pollutants, and climate change. In spite of the severe population decline, the olive ridley turtle breeding populations on the Pacific coast of Mexico appear to be resilient, evidenced by the increasing population.

Critical Habitat

No critical habitat has been designated for the breeding population of the Pacific coast of Mexico or the range-wide, threatened population of olive ridley turtles.

Recovery Goals

There has not been a Recovery Plan prepared specifically for the range-wide, threatened population or breeding populations of the Pacific coast of Mexico of olive ridley turtles. The 1998 Recovery Plan was prepared for olive ridley turtles found in the U.S. Pacific. Olive ridley turtles found in the Pacific could originate from the Pacific Coast of Mexico or from another nesting population. As such, the recovery goals in the 1998 Recovery Plan for the U.S. Pacific olive ridley turtle can apply to both ESA-listed populations. See the 1998 Recovery Plan for the U.S. Pacific olive ridley turtles for complete downlisting/delisting criteria for their recovery goals. The following items were the recovery criteria identified to consider delisting:

1. All regional stocks that use U.S. waters have been identified to source beaches based on reasonable geographic parameters.
2. Foraging populations are statistically significantly increasing at several key foraging grounds within each stock region.
3. All females estimated to nest annually at source beaches are either stable or increasing for over ten years.
4. Management plan based on maintaining sustained populations for sea turtles in effect.
5. International agreements in place to protect shared stocks.

7 ENVIRONMENTAL BASELINE

The “environmental baseline” includes the past and present impacts of all Federal, state, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of state or private actions which are contemporaneous with the consultation in process (50 C.F.R. §402.02). The environmental baseline for this opinion includes the effects of several activities that affect the survival and recovery of ESA-listed resources in the SURTASS LFA sonar action area.

7.1 Climate Change

There is a large and growing body of literature on past, present, and future impacts of global climate change, exacerbated and accelerated by human activities. Effects of climate change include sea level rise, increased frequency and magnitude of severe weather events, changes in air and water temperatures, and changes in precipitation patterns, all of which are likely to impact ESA resources. NOAA’s climate information portal provides basic background information on these and other measured or anticipated climate change effects (see https://www.climate.gov).

In order to evaluate the implications of different climate outcomes and associated impacts throughout the 21st century, many factors have to be considered. The amount of future greenhouse gas emissions is a key variable. Developments in technology, changes in energy generation and land use, global and regional economic circumstances, and population growth must also be considered.

A set of four scenarios was developed by the Intergovernmental Panel on Climate Change (IPCC) to ensure that starting conditions, historical data, and projections are employed consistently across the various branches of climate science. The scenarios are referred to as representative concentration pathways (RCPs), which capture a range of potential greenhouse gas emissions pathways and associated atmospheric concentration levels through 2100 (IPCC 2014). The RCP scenarios drive climate model projections for temperature, precipitation, sea level, and other variables: RCP2.6 is a stringent mitigation scenario; RCP2.5 and RCP6.0 are intermediate scenarios; and RCP8.5 is a scenario with no mitigation or reduction in the use of fossil fuels. The IPCC future global climate predictions (2014 and 2018) and national and regional climate predictions included in the Fourth National Climate Assessment for U.S. states and territories (2018) use the RCP scenarios.

The increase of global mean surface temperature change by 2100 is projected to be 0.3 to 1.7°C under RCP2.6, 1.1 to 2.6°C under RCP 4.5, 1.4 to 3.1°C under RCP6.0, and 2.6 to 4.8°C under RCP8.5, with the Arctic region warming more rapidly than the global mean under all scenarios (IPCC 2014). The Paris Agreement aims to limit the future rise in global average temperature to 2°C, but the observed acceleration in carbon emissions over the last 15 to 20 years, even with a lower trend in 2016, has been consistent with higher future RCP scenarios such as RCP8.5 (Hayhoe et al. 2018).

The globally-averaged combined land and ocean surface temperature data, as calculated by a linear trend, show a warming of approximately 1.0°C from 1901 through 2016 (Hayhoe et al. 2018). The IPCC Special Report on the Impacts of Global Warming (2018) (IPCC 2018) noted that human-induced warming reached temperatures between 0.8 and 1.2°C above pre-industrial levels in 2017, likely increasing between 0.1 and 0.3°C per decade. Warming greater than the global average has already been experienced in many regions and seasons, with most land regions experiencing greater warming than over the ocean (Allen et al. 2018). Annual average temperatures have increased by 1.8°C across the contiguous U.S. since the beginning of the 20th century with Alaska warming faster than any other state and twice as fast as the global average since the mid-20th century (Jay et al. 2018). Global warming has led to more frequent heatwaves in most land regions and an increase in the frequency and duration of marine heatwaves (Allen et al. 2018). Average global warming up to 1.5°C as compared to pre-industrial levels is expected to lead to regional changes in extreme temperatures, and increases in the frequency and intensity of precipitation and drought (Allen et al. 2018).

Several of the most important threats contributing to the extinction risk of ESA-listed species, particularly those with a calcium carbonate skeleton such as corals and mollusks as well as

species for which these animals serve as prey or habitat, are related to global climate change. The main concerns regarding impacts of global climate change on coral reefs and other calcium carbonate habitats generally, and on ESA-listed corals and mollusks in particular, are the magnitude and the rapid pace of change in greenhouse gas concentrations (e.g., carbon dioxide and methane) and atmospheric warming since the Industrial Revolution in the mid-19th century. These changes are increasing the warming of the global climate system and altering the carbonate chemistry of the ocean [ocean acidification; (IPCC 2014)]. As carbon dioxide concentrations increase in the atmosphere, more carbon dioxide is absorbed by the oceans, causing lower pH and reduced availability of calcium carbonate. Because of the increase in carbon dioxide and other greenhouse gases in the atmosphere since the Industrial Revolution, ocean acidification has already occurred throughout the world's oceans, including in the Pacific Ocean, and is predicted to increase considerably between now and 2100 (IPCC 2014).

Additional consequences of climate change include increased ocean stratification, decreased sea-ice extent, altered patterns of ocean circulation, and decreased ocean oxygen levels (Doney et al. 2012). Since the early 1980s, the annual minimum sea ice extent (observed in September each year) in the Arctic Ocean has decreased at a rate of 11 to 16 percent per decade (Jay et al. 2018). Further, ocean acidity has increased by 26 percent since the beginning of the industrial era (IPCC 2014) and this rise has been linked to climate change. Climate change is also expected to increase the frequency of extreme weather and climate events including, but not limited to, cyclones, tropical storms, heat waves, and droughts (IPCC 2014).

Climate change has the potential to impact species abundance, geographic distribution, migration patterns, and susceptibility to disease and contaminants, as well as the timing of seasonal activities and community composition and structure (Macleod et al. 2005); (Robinson et al. 2005); (Kintisch 2006); (Learmonth et al. 2006a); (Mcmahon and Hays 2006); (Evans and Bjørge 2013); (IPCC 2014). Though predicting the precise consequences of climate change on highly mobile marine species is difficult (Simmonds and Isaac 2007a), recent research has indicated a range of consequences already occurring. For example, in sea turtles, sex is determined by the ambient sand temperature (during the middle third of incubation) with female offspring produced at higher temperatures and males at lower temperatures within a thermal tolerance range of 25 to 35°C (Ackerman 1997). Increases in global temperature could skew future sex ratios toward higher numbers of females (NMFS and USFWS 2007aa; NMFS and USFWS 2007cb; NMFS and USFWS 2013aa; NMFS and USFWS 2013bb; NMFS and USFWS 2015). These impacts will be exacerbated by sea level rise. The loss of habitat because of climate change could be accelerated due to a combination of other environmental and oceanographic changes such as an increase in the frequency of storms and/or changes in prevailing currents, both of which could lead to increased beach loss via erosion (Antonelis et al. 2006); (Baker et al. 2006).

As expressed above, marine species ranges are expected to shift as they align their distributions to match their physiological tolerances under changing environmental conditions (Doney et al.

2012). For example, blue whales, as predators that specialize in eating krill, are likely to change their distribution in response to changes in the distribution of krill (Payne et al. 1986); (Payne et al. 1990); (Clapham et al. 1999). (Pecl and Jackson 2008) predicted climate change will likely result in squid that hatch out smaller and earlier, undergo faster growth over shorter life-spans, and mature younger at a smaller size. This could have negative consequences for species such as sperm whales, whose diets can be dominated by cephalopods. For ESA-listed species that undergo long migrations, if either prey availability or habitat suitability is disrupted by changing ocean temperatures regimes, the timing of migration can change or negatively impact population sustainability (Simmonds and Eliott 2009).

As discussed above, changes in the marine ecosystem caused by global climate change (e.g., ocean acidification, salinity, oceanic currents, dissolved oxygen levels, nutrient distribution) could influence the distribution and abundance of lower trophic levels (e.g., phytoplankton, zooplankton, submerged aquatic vegetation, crustaceans, mollusks, forage fish), ultimately affecting primary foraging areas of ESA-listed species including marine mammals, sea turtles, and fish. Marine species ranges are expected to shift as they align their distributions to match their physiological tolerances under changing environmental conditions (Doney et al. 2012). (Hazen et al. 2012) examined top predator distribution and diversity in the Pacific Ocean in light of rising sea surface temperatures using a database of electronic tags and output from a global climate model. They predicted up to a 35 percent change in core habitat area for some key marine predators in the Pacific Ocean, with some species predicted to experience gains in available core habitat and some predicted to experience losses. Notably, leatherback turtles were predicted to gain core habitat area, whereas loggerhead turtles and blue whales were predicted to experience losses in available core habitat. (Mcmahon and Hays 2006) predicted increased ocean temperatures will expand the distribution of leatherback turtles into more northern latitudes. The authors noted this is already occurring in the Atlantic Ocean. (Macleod 2009) estimated, based upon expected shifts in water temperature, 88 percent of cetaceans will be affected by climate change, with 47 percent predicted to experience unfavorable conditions (e.g., range contraction). (Willis-Norton et al. 2015) acknowledged there will be both habitat loss and gain, but overall climate change could result in a 15 percent loss of core pelagic habitat for leatherback turtles in the eastern South Pacific Ocean.

This review provides some examples of impacts to ESA-listed species and their habitats that may occur as the result of climate change. While it is difficult to accurately predict the consequences of climate change to a particular species or habitat, a range of consequences are expected that are likely to change the status of the species and the condition of their habitats.

7.2 Oceanic Temperature Regimes

Oceanographic conditions in the Atlantic and Pacific Oceans can be altered due to periodic shifts in atmospheric patterns caused by the Southern oscillation in the Pacific Ocean, which leads to El Niño and La Niña events, the Pacific decadal oscillation, and the North Atlantic oscillation. These climatic events can alter habitat conditions and prey distribution for ESA-listed species in

the action area (Benson and Trites 2002; Stabeno et al. 2004; Mundy and Cooney 2005). For example, decade-scale climatic regime shifts have been related to changes in zooplankton in the North Atlantic Ocean (Fromentin and Planque 1996), and decadal trends in the North Atlantic oscillation (Hurrell 1995) can affect the position of the Gulf Stream (Taylor et al. 1998) and other circulation patterns in the North Atlantic Ocean that act as migratory pathways for various marine species, especially fish.

The Pacific decadal oscillation is the leading mode of variability in the North Pacific and operates over longer periods than either El Niño or La Niña/Southern Oscillation events and is capable of altering sea surface temperature, surface winds, and sea level pressure (Mantua and Hare 2002; Stabeno et al. 2004). During positive Pacific decadal oscillations, the northeastern Pacific experiences above average sea surface temperatures while the central and western Pacific Ocean undergoes below-normal sea surface temperatures (Royer 2005). Warm Pacific decadal oscillation regimes, as occurs in El Niño events, tends to decrease productivity along the U.S. west coast, as upwelling typically diminishes (Hare et al. 1999; Childers et al. 2005). Recent sampling of oceanographic conditions just south of Seward, Alaska has revealed anomalously cold conditions in the Gulf of Alaska from 2006 through 2009, suggesting a shift to a colder Pacific decadal oscillation phase. More research needs to be done to determine if the region is indeed shifting to a colder Pacific decadal oscillation phase in addition to what effects these phase shifts have on the dynamics of prey populations important to ESA-listed cetaceans throughout the Pacific action area. A shift to a colder decadal oscillation phase would be expected to impact prey populations, although the magnitude of this effect is uncertain.

There is some evidence to suggest that physical oceanographic patterns during the El Niño phenomenon affect the aggregations of marine debris in the northwest Hawaiian Islands. The North Pacific Ocean subtropical high convergence zone is an area where marine debris accumulates. In El Niño years, the subtropical high convergence zone becomes larger, more intense, and is located further south during winter, within the range of Hawaiian monk seals in the northwest Hawaiian Islands (Donohue and Foley 2007). Hawaiian monk seals experienced higher rates of entanglement during El Niño years, likely because of being exposed to the marine debris present in the subtropical high convergence zone.

In addition to period variation in weather and climate patterns that affect oceanographic conditions in the action area, longer terms trends in climate change and/or variability also have the potential to alter habitat conditions suitable for ESA-listed species in the action area on a much longer time scale. For example, from 1906 through 2006, global surface temperatures have risen 0.74° Celsius and this trend is continuing at an accelerating pace. Possible effects of this trend in climate change and/or variability for ESA-listed marine species in the action area include the alteration of community composition and structure, changes to migration patterns or community structure, changes to species abundance, increased susceptibility to disease and contaminants, and altered timing of breeding and nesting (Macleod et al. 2005; Robinson et al. 2005; Kintisch 2006; Learmonth et al. 2006b; Mcmahon and Hays 2006). Climate change can

influence reproductive success by altering prey availability, as evidenced by the low success of Northern elephant seals (Mirounga angustirostris) during El Niño periods (McMahon and Burton 2005) as well as data suggesting that sperm whale females have lower rates of conception following periods of unusually warm sea surface temperature (Whitehead et al. 1997). However, gaps in information and the complexity of climatic interactions complicate the ability to predict the effects that climate change and/or variability may have to these species from year to year in the action area (Kintisch 2006; Simmonds and Isaac 2007b).

7.3 Disease

Acute toxicity events may result in mass mortalities; repeated exposure to lower level contaminants may result in immune suppression and/or endocrine disruption (Atkinson et al. 2008). Pinnipeds may become exposed to infectious diseases (e.g., Chlamydia and leptospirosis) through polluted waterways (Aguirre et al. 2007). Infectious diseases are recognized as a significant threat to Hawaiian monk seals. In addition to polluted runoff water, other avenues for exposure include contact with other animals—marine mammals, and domestic and feral animals (NMFS 2016c). Toxoplasmosis has been observed in Hawaiian monks seals (Honnold et al. 2005), a disease that causes multiple organ dysfunction and failure. Recently, toxoplasmosis cause the death of three Hawaiian monk seals on Oahu in May 2018; in total, 11 monk seals have died since 2001 as a result of the disease. Morbilliviruses, such as canine distemper virus, phocine distemper virus, and cetacean mobilluvirus, also pose threats to Hawaiian monk seals (Robinson et al. 2018). Because of its small population size, Hawaiian monk seals are especially at risk from infectious disease. In 2015, NOAA and partners worked to implement a vaccination program on Oahu (Robinson et al. 2018). The 2016 Hawaiian Monk Seal Management Plan identifies several activities to evaluate and reduce the risk of disease in monk seals (NMFS 2016a).

Mass mortality events of marine mammals, including cetaceans, have been reported more frequently since 1978, with viruses, bacteria, and parasites commonly listed as the cause (Gulland and Hall 2007). Morbillivirus was reported in a neonate female sperm whale that stranded and died in Oahu; the individual was also infected with the bacterial genus Brucella (West et al. 2015). In 1987, 14 humpback whales died in Cape Cod Bay, Massachusetts, after consuming mackerel containing a dinoflagellate toxin (Geraci et al. 1989).

Green sea turtles are susceptible to natural mortality from fibropapillomatosis disease. Fibropapillomatosis results in the growth of tumors on soft external tissues (flippers, neck, tail, etc.), the carapace, the eyes, the mouth, and internal organs (gastrointestinal tract, heart, lungs, etc. (Jacobson et al. 1989; Herbst 1994; Aguirre et al. 2002). These tumors range in size from 0.1 cm (0.04 in) to greater than 30 cm (11.8 in) in diameter and may affect swimming, vision, feeding, and organ function (Jacobson et al. 1989; Herbst 1994; Aguirre et al. 2002). Presently, scientists are unsure of the exact mechanism causing this disease, but it is likely related to both an infectious agent, such as a virus (Herbst et al. 1995), and environmental conditions (e.g., habitat degradation, pollution, low wave energy, and shallow water) (Foley et al. 2005).

Fibropapillomatosis is cosmopolitan, but it affects large numbers of animals in specific areas, including Hawaii and Florida (Jacobson 1990; Jacobson et al. 1991; Herbst 1994).

Fibropapillomatosis is the most significant cause of stranding and mortality in green turtles in Hawaii, accounting for 28 percent of strandings with an 88 percent mortality rate of afflicted stranded sea turtles (Chaloupka et al. 2008). While the disease appears to have regressed over time (Chaloupka et al. 2009), it persists in the population at levels of spatial variability (Van Houtan et al. 2010). Van Houtan et al. (2010) also suggest a potential relationship exists between the expression of fibropapillomatosis and the State's land use, wastewater management practices, and invasive macro algae.

7.4 Invasive Species

Invasive species have been referred to as one of the top four threats to the world's oceans (Raaymakers and Hilliard 2002; Raaymakers 2003; Terdalkar et al. 2005; Wambiji et al. 2007; Pughiuc 2010). A variety of vectors are thought to have introduced non-native species including, but not limited to, aquarium and pet trades, recreation, and ballast water discharges from ocean-going vessels. Non-native aquatic species can be introduced through infested stock for aquaculture and fishery enhancement, ballast water discharge, and from the pet and recreational fishing industries. Non-native species can reduce native species abundance and distribution, and reduce local biodiversity by out-competing native species for food and habitat. They may also displace food items preferred by native predators, disrupting the natural food web. An example of indirect predatory effects caused by an invasive species is the European green crab, which has invaded both the east and west coasts of the U.S., resulting in trophic scale effects to ecosystems in both regions (Grosholz and Ruiz 1996). Invasive plants can cause widespread habitat alteration, including native plant displacement, changes in benthic and pelagic animal communities, altered sediment deposition, altered sediment characteristics, and shifts in chemical processes such as nutrient cycling (Grout et al. 1997; Wigand et al. 1997; Ruiz et al. 1999). Introduced seaweeds alter habitat by colonizing previously unvegetated areas, while algae form extensive mats that exclude most native taxa, dramatically reducing habitat complexity and the ecosystem services provided by it (Wallentinus and Nyberg 2007). Invasive algae can alter native habitats through a variety of impacts including trapping sediment, reducing the number of suspended particles that reach the benthos for benthic suspension and deposit feeders, reducing light availability, and adverse impacts to foraging for a variety of animals (Gribsholt and Kristensen 2002; Britton-Simmons 2004; Levi and Francour 2004; Sanchez et al. 2005). Pathogens and species with toxic effects not only have direct effects on listed species, but also may affect essential critical habitat features or indirectly affect the species through ecosystem-mediated impacts. There are a number of non-native species that have the potential to either expel toxins at low levels, only becoming problematic for other members of the ecosystem if their population grows to very large sizes, resulting in very large amounts of toxins being released.

There are a total of 333 non-native species, and another 130 cryptogenic species (i.e., unknown origin), documented as part of the marine and estuarine biota of the six largest Hawaiian islands from Kauai to Hawaii (Carlton and Eldredge 2015). The greatest proportion of non-native and cryptogenic species are found in the majors harbors of Oahu, which receive the large majority of all vessel traffic in the Hawaiian Islands (Coles and Eldredge 2002). Approximately 20 percent of the benthic algae, fish, and macroinvertebrate species found these harbors are either non-native or cryptogenic. Algal species have become nuisance invaders of many Hawaiian reefs (Smith et al. 2002). With the exception of Kaneohe Bay, the largest embayment in Hawaii with a history of urban impact, few nonindigenous fish or invertebrates have been detected on Hawaiian reefs (Coles and Eldredge 2002). ESA-listed Hawaiian monk seals could be impacted by invasive species in Hawaii, although there are no studies indicating this is occurring. In addition, Pacific Island ESA-listed sea turtles have experienced predation from several invasive species that feed off both eggs and hatchlings. These invasive predators include mongooses, cats, pigs, and rats which may all present threats to ESA-listed sea turtles in the action area (NMFS 2016d).

7.5 Pollution

Anthropogenic activities such as discharges from wastewater systems, dredging, ocean dumping and disposal, aquaculture, and additional impacts from coastal development are known to degrade coastal waters utilized by ESA-listed marine mammals and sea turtles in the action area. Multiple municipal, industrial, and household sources as well as atmospheric transport introduce various pollutants such as pesticides, hydrocarbons, organochlorides, and other pollutants that may cause adverse health effects to ESA-listed marine mammals (Iwata et al. 1993; Grant and Ross 2002; Ross 2002b; Garrett 2004; Hartwell 2004). The accumulation of persistent pollutants through trophic transfer may cause mortality and sub-lethal effects including immune systems abnormalities, endocrine disruption and reproductive effects (Krahn et al. 2007b). Recent efforts have led to improvements in regional water quality in some parts of the action area, although the more persistent chemicals are still detected and are expected to endure for years (Grant and Ross 2002).

7.5.1 Marine Debris

Debris can be introduced into the marine environment by its improper disposal, accidental loss, transport from land-based sources, or natural disasters (e.g., continental flooding and tsunamis) (Watters et al. 2010), and can include plastics, glass, polystyrene foam, rubber, derelict fishing gear, derelict vessels, or military expendable materials. Marine debris accumulates in gyres throughout the oceans. Despite debris removal and outreach to heighten public awareness, marine debris in the environment has not been reduced (Academies 2008) and continues to accumulate in the ocean and along shorelines within the action area.

Marine debris affects marine habitats and marine life worldwide, primarily by entangling or choking individuals that encounter it. Entanglement in marine debris can lead to injury, infection, and reduced mobility, increased susceptibility to predation, decreased feeding ability, fitness consequences, and mortality for all ESA-listed species in the action area. Entanglement can also

result in drowning for air breathing marine species including sea turtles, cetaceans, and pinnipeds. Marine debris ingestion can lead to intestinal blockage, which can impact feeding ability and lead to injury or death. Data on marine debris in some locations of the action area is largely lacking; therefore, it is difficult to draw conclusions as the extent of the problem and its impacts on populations of ESA-listed species that inhabit the area.

Sea turtles can mistake plastic bags for jellyfish, which are eaten by sea turtle species in early life phases, and exclusively by leatherback turtles throughout their lives. One study found plastic in 37 percent of dead leatherback turtles and determined that nine percent of those deaths were a direct result of plastic ingestion (Mrosovsky et al. 2009). Other marine debris, including derelict fishing gear and cargo nets, can entangle and drown sea turtles of all life stages. For example, in a study assessing sea turtle nesting locations in debris dense study sites, Triessnig et al. (2012) found that hatchlings became severely entangled in fishing nets and entrapped in simple containers such as plastic cups and cut-open canisters. Triessnig et al. (2012) discovered hatchlings never avoided contact with the debris or reversed their direction to escape. In addition, in a study examining ingestion in 115 green and hawksbill turtles stranded in Queensland, Schuyler et al. (2012) found that the probability of debris ingestion was inversely correlated with size (curved carapace length), and when broken down into size classes, smaller pelagic sea turtles were significantly more likely to ingest debris than larger benthic feeding turtles. Parker et al. (2005) conducted a diet analysis of 52 loggerhead turtles collected as bycatch from 1990 to 1992 in the high seas drift gillnet fishery in the central north Pacific Ocean. The authors found that 34.6 percent of the individuals sampled had anthropogenic debris in their stomachs (e.g., plastic, Styrofoam, paper, rubber, etc.). Similarly, a study of green turtles found that 61 percent of those observed stranded had ingested some form of marine debris, including rope or string, which may have originated from fishing gear (Bugoni et al. 2001). In 2008, two sperm whales stranded along the California coast, with an assortment of fishing related debris (e.g., net scraps, rope) and other plastics inside their stomachs (Jacobsen et al. 2010). One whale was emaciated, and the other had a ruptured stomach. It was suspected that gastric impaction was the cause of both deaths. Jacobsen (2010) speculated that the debris likely accumulated over many years, possibly in the North Pacific gyre that would carry derelict Asian fishing gear into eastern Pacific waters (Jacobsen et al. 2010).

Plastic debris is a major concern because it degrades slowly and many plastics float. The floating debris is transported by currents throughout the oceans and has been discovered accumulating in oceanic gyres (Law et al. 2010). Additionally, plastic waste in the ocean chemically attracts hydrocarbon pollutants such as polychlorinated biphenyls (PCBs) and DDT (dichlorodiphenyltrichloroethane). Fishes, marine mammals, and sea turtles can mistakenly consume these wastes containing elevated levels of toxins instead of their prey. In the North Pacific Subtropical Gyre it is estimated that the fishes in this area are ingesting 10,886,216 to 21,772,433 kilograms (12,000 to 24,000 U.S. tons) of plastic debris a year (Davison and Asch 2011). For these reasons, it is expected ESA-listed species may be exposed to marine debris over the course of the action.

7.5.1 Pesticides and Contaminants

Exposure to pollution and contaminants has the potential to cause adverse health effects in marine species. Marine ecosystems receive pollutants from a variety of local, regional, and international sources, and their levels and sources are therefore difficult to identify and monitor (Grant and Ross 2002). Marine pollutants come from multiple municipal, industrial, and household as well as from atmospheric transport (Iwata 1993; Grant and Ross 2002; Garrett 2004; Hartwell 2004). Contaminants may be introduced by rivers, coastal runoff, wind, ocean dumping, dumping of raw sewage by boats and various industrial activities, including offshore oil and gas or mineral exploitation (Grant and Ross 2002; Garrett 2004; Hartwell 2004).

Research has correlated contaminant exposure to possible adverse health effects in marine mammals. The accumulation of persistent organic pollutants, including polychlorinated-biphenyls, dibenzo-p-dioxins, dibenzofurans, and related compounds, through trophic transfer may cause mortality and sub-lethal effects in long-lived higher trophic level animals such as cetaceans (Waring et al. 2016a), including immune system abnormalities, endocrine disruption, and reproductive effects (Krahn et al. 2007a). Persistent organic pollutants may also facilitate disease emergence and lead to the creation of susceptible “reservoirs” for new pathogens in contaminated marine mammal populations (Ross 2002a). Recent efforts have led to improvements in regional water quality and monitored pesticide levels have declined, although the more persistent chemicals are still detected and are expected to endure for years (Law 2014) (Mearns 2001; Grant and Ross 2002).

Additionally, due to their large amount of blubber and fat, marine mammals readily accumulate lipid-soluble contaminants (O'Hara and Rice 1996). Persistent organic pollutants were present in the blubber of Hawaiian monk seals in the main and Northwest Hawaiian Islands. Adult males had the highest levels of persistent organic pollutants compared to adult females and juveniles (Lopez et al. 2012).

In sea turtles, heavy metals have been found in a variety of tissues in levels that increase with sea turtle size (Godley 1999; Sakai et al. 2000; Anan et al. 2001; Fujihara et al. 2003; Gardner et al. 2006; Storelli et al. 2008; Barbieri 2009; García-Fernández et al. 2009). Cadmium has been found in leatherback turtles at the highest concentration compared to any other marine vertebrate (Gordon et al. 1998; Caurant et al. 1999). Newly emerged hatchlings have higher concentrations than are present when laid, suggesting that metals may be accumulated during incubation from surrounding sands (Sahoo et al. 1996). Arsenic has been found to be very high in green turtle eggs (Van De Merwe et al. 2009).

Concentrations of PCBs are reportedly equivalent to those in some marine mammals, with liver and adipose levels of at least one congener being exceptionally high (PCB 209: 500 to 530 ng/g) wet weight) (Davenport et al. 1990; Oros et al. 2009). Levels of PCBs found in green turtle eggs are considered far higher than what is fit for human consumption (Van De Merwe et al. 2009).

Organochlorines have the potential to suppress the immune system of loggerhead turtles and may affect metabolic regulation (Keller et al. 2004; Keller et al. 2006; Oros et al. 2009). These contaminants should cause deficiencies in endocrine, developmental, and reproductive health (Storelli et al. 2007), and are known to depress immune function in loggerhead turtles (Keller et al. 2006). Females from sexual maturity through reproductive life should have lower levels of contaminants than males because contaminants are shared with progeny through egg formation. Exposure to sewage effluent may also result in green turtle eggs harboring antibiotic resistant strains of bacteria (Al-Bahry et al. 2009).

7.5.1 Hydrocarbons

Exposure to hydrocarbons released into the environment via oil spills and other discharges pose risks to marine species. Marine mammals are generally able to metabolize and excrete limited amounts of hydrocarbons, but exposure to large amounts of hydrocarbons and chronic exposure over time pose greater risks (Grant and Ross 2002). Acute exposure of marine mammals to petroleum products causes changes in behavior and may directly injure animals (Geraci 1990). Cetaceans have a thickened epidermis that greatly reduces the likelihood of petroleum toxicity from skin contact with oils (Geraci 1990), but they may inhale these compounds at the water's surface and ingest them while feeding (Matkin and Saulitis 1997). Hydrocarbons also have the potential to impact prey populations and therefore may affect ESA-listed species indirectly by reducing food availability.

Oil can also be hazardous to sea turtles, with fresh oil causing significant mortality and morphological changes in hatchlings. Sea turtles are known to ingest and attempt to ingest tar balls, which can block their digestive systems, impairing foraging or digestion and potentially causing death (NOAA 2003), ultimately reducing growth, reproductive success, as well as increasing mortality and predation risk (Fraser 2014). Tar balls were found in the digestive tracts of 63 percent of post hatchling loggerheads in 1993 following an oil spill and 20 percent of the same species and age class in 1997 (Fraser 2014). Oil exposure can also cause acute damage on direct exposure to oil, including skin, eye, and respiratory irritation, reduced respiration, burns to mucous membranes such as the mouth and eyes, diarrhea, gastrointestinal ulcers and bleeding, poor digestion, anemia, reduced immune response, damage to kidneys or liver, cessation of salt gland function, reproductive failure, and death (Vargo et al. 1986a; Vargo et al. 1986b; Vargo et al. 1986c; NOAA 2003; NOAA 2010). Nearshore spills or large offshore spills can oil beaches on which sea turtles lay their eggs, causing birth defects or mortality in the nests (NOAA 2003; NOAA 2010).

7.6 Commercial Fisheries and Incidental Capture

Fisheries constitute an important and widespread use of ocean resources throughout the action area. Fisheries can adversely affect fish populations, other species, and habitats. Direct effects of fisheries interactions include entanglement and entrapment, which can lead to fitness consequences or mortality as a result of injury or drowning. Indirect effects include reduced prey availability and destruction of habitat. Potential impacts of fisheries include overfishing of

targeted species and bycatch, both of which negatively affect fish stocks and other marine resources. Bycatch is the capture of fish, marine mammals, sea turtles, marine birds, and other non-targeted species that occurs incidental to normal fishing operations. Use of mobile fishing gear, such as bottom trawls, disturbs the seafloor and reduces structural complexity. Indirect impacts of trawls include increased turbidity, alteration of surface sediment, removal of prey (leading to declines in predator abundance), removal of predators, ghost fishing (i.e., list fishing gear continuing to ensnare fish and other marine animals), and generation of marine debris. Lost gill nets, purse seines, and long-lines may foul and disrupt bottom habitats and have the potential to entangle or be ingested by marine mammals.

In 2016, eight of the top ten major fish capture producing countries were located near or on the boundary of the current action area: China, the U.S., Indonesia, Russia, Japan, India, Vietnam, Malaysia, and the Philippines (See Figure 32). Overall, the western and central North Pacific and eastern Indian oceans (the SURTASS LFA action area) account for approximately 42 million metric tons of captured fish totals amounting to nearly half of all worldwide capture production estimates for 2016 (See Figure 33).

Country	Production (tonnes)			% Variation		Variation, 2015 to 2016 (tonnes)
	Average 2005–2014	2015	2016	2005–2014 (average) to 2016	2015 to 2016	
China	13 189 273	15 314 000	15 246 234	15.6	–0.4	–67 766
Indonesia	5 074 932	6 216 777	6 109 783	20.4	–1.7	–106 994
United States of America	4 757 179	5 019 399	4 897 322	2.9	–2.4	–122 077
Russian Federation	3 601 031	4 172 073	4 466 503	24.0	7.1	294 430
Peru Total	6 438 839	4 786 551	3 774 887	–41.4	–21.1	–1 011 664
Excluding anchoveta	989 918	1 016 631	919 847	–7.1	–9.5	–96 784
India	3 218 050	3 497 284	3 599 693	11.9	2.9	102 409
Japan*	3 992 458	3 423 099	3 167 610	–20.7	–7.5	–255 489
Viet Nam	2 081 551	2 607 214	2 678 406	28.7	2.7	71 192
Norway	2 348 154	2 293 462	2 033 560	–13.4	–11.3	–259 902
Philippines	2 155 951	1 948 101	1 865 213	–13.5	–4.3	–82 888
Malaysia	1 387 577	1 486 050	1 574 443	13.5	5.9	88 393
Chile Total	3 157 946	1 786 249	1 499 531	–52.5	–16.1	–286 718
Excluding anchoveta	2 109 785	1 246 154	1 162 095	–44.9	–6.7	–84 059
Morocco	1 074 063	1 349 937	1 431 518	33.3	6.0	81 581
Republic of Korea	1 746 579	1 640 669	1 377 343	–21.1	–16.0	–263 326
Thailand	1 830 315	1 317 217	1 343 283	–26.6	2.0	26 066
Mexico	1 401 294	1 315 851	1 311 089	–6.4	–0.4	–4 762
Myanmar*	1 159 708	1 107 020	1 185 610	2.2	7.1	78 590
Iceland	1 281 597	1 318 916	1 067 015	–16.7	–19.1	–251 901
Spain	939 384	967 240	905 638	–3.6	–6.4	–61 602
Canada	914 371	823 155	831 614	–9.1	1.0	8 459
Taiwan, Province of China	960 193	989 311	750 021	–21.9	–24.2	–239 290
Argentina	879 839	795 415	736 337	–16.3	–7.4	–59 078
Ecuador	493 858	643 176	715 357	44.9	11.2	72 181
United Kingdom	631 398	65 451 506	701 749	11.1	–0.4	–2 753
Denmark	735 966	868 892	670 207	–8.9	–22.9	–198 685
Total 25 major countries	**65 451 506**	**66 391 560**	**63 939 966**	**–2.3**	**–3.7**	**–2 451 594**
Total other 170 countries	**14 326 675**	**14 856 282**	**15 336 882**	**7.1**	**3.2**	**480 600**
World total	**79 778 181**	**81 247 842**	**79 276 848**	**–0.6**	**–2.4**	**–1 970 994**
Share of 25 major countries	***82.0%***	***81.7%***	***80.7%***			

* Production figures for 2015 and 2016 are FAO estimates.

Figure 32. Major Marine Capture Producer Countries from 2015 to 2016 (FAO 2018)

Fishing area code	Fishing area name	Production (tonnes)			% Variation		Variation, 2015 to 2016 (tonnes)
		Average 2005–2014	2015	2016	2005–2014 (average) to 2016	2015 to 2016	
Inland							
01	Africa – inland waters	2 609 727	2 804 629	2 863 916	9.7	2.1	59 287
02	America, North – inland waters	178 896	207 153	260 785	45.8	25.9	53 632
03	America, South – inland waters	384 286	362 670	340 804	–11.3	–6.0	–21 866
04	Asia – inland waters	6 959 783	7 584 414	7 708 776	10.8	1.6	124 362
05	Europe – inland waters*	373 523	431 179	440 790	18.0	2.2	9 611
06	Oceania – inland waters	17 978	18 030	17 949	–0.2	–0.4	–81
Marine							
21	Atlantic, Northwest	2 041 599	1 842 787	1 811 436	–11.3	–1.7	–31 351
27	Atlantic, Northeast	8 654 911	9 139 199	8 313 901	–3.9	–9.0	–825 298
31	Atlantic, Western Central	1 344 651	1 414 318	1 563 262	16.3	10.5	148 944
34	Atlantic, Eastern Central	4 086 427	4 362 180	4 795 171	17.3	9.9	432 991
37	Mediterranean and Black Sea	1 421 025	1 314 386	1 236 999	–13.0	–5.9	–77 387
41	Atlantic, Southwest	2 082 248	2 427 872	1 563 957	–24.9	–35.6	–863 915
47	Atlantic, Southeast	1 425 775	1 677 969	1 688 050	18.4	0.6	10 081
51	Indian Ocean, Western	4 379 053	4 688 848	4 931 124	13.9	5.2	242 276
57	Indian Ocean, Eastern	5 958 972	6 359 691	6 387 659	7.2	0.4	27 968
61	Pacific, Northwest	20 698 014	22 057 759	22 411 224	7.7	1.6	353 465
67	Pacific, Northeast	2 871 126	3 164 604	3 092 529	7.7	–2.3	–72 075
71	Pacific, Western Central	11 491 444	12 625 068	12 742 955	10.9	0.9	117 887
77	Pacific, Eastern Central	1 881 996	1 675 065	1 656 434	–12.0	–1.1	–18 631
81	Pacific, Southwest	613 701	551 534	474 066	–22.8	–14.0	–77 468
87	Pacific, Southeast	10 638 882	7 702 885	6 329 328	–40.5	–17.8	–1 373 557
18, 48, 58, 88	Arctic and Antarctic areas	188 360	243 677	278 753	48.0	14.4	35 076
World total		**90 302 377**	**92 655 917**	**90 909 868**	**0.7**	**–1.9**	**–1 746 049**

* Includes the Russian Federation.

Figure 33. Major Marine Fishing Areas from 2015 to 2016 (FAO 2018)

Fisheries interactions are a major threat to pinnipeds through several mechanisms: prey reduction, intentional shootings, incidental bycatch, and entanglement in fishing gear. Reduced quantity or quality of prey appears to be a major threat to several pinniped species, as evidenced by population declines, reduced body size/condition, low birth rates, and high juveniles mortality rates (Trites and Donnelly 2003; Baker 2008). Pinnipeds are also intentionally shot by fishermen as a result of actual or perceived competition for fish. An estimated 50 to 1,180 Steller sea lions are shot annually (Atkinson et al. 2008). This includes eight Steller sea lions that were reported to be illegally shot in the Copper River Delta of Alaska (Muto et al. 2019). Similarly, on the Main Hawaiian Islands, Hawaiian monk seals have been killed in recent years, with at least four individuals shot, and three dying from traumatic head injury (Carretta et al. 2019).

Pinnipeds are also injured and killed accidentally as a result of being hooked by longline fisheries, entangled in fishing line, and entangled in gillnet, trawl, and other net-based fisheries. Commercial fishing is estimated to incidentally kill approximately 30 Steller sea lions annually (Atkinson et al. 2008). In addition, hookings and entanglement in fishing gear represent major threats to Hawaiian monk seals. From 1976 to 2014, there were 140 documented reports of Hawaiian monk seal hooking and entanglements on the main Hawaiian Islands (NMFS 2016c). Aside from actively fished gear, derelict fishing gear (accidentally lost or intentionally discarded or abandoned fishing lines, nets, pots, traps, or other gear associated with commercial or recreational fishing) also represents an entanglement risk for pinnipeds. Derelict gear is one of the primary threats to the Hawaiian monk seal, with annual rates of entanglement in fishing gear ranging from four to 78 percent of the total estimated population (Donohue and Foley 2007). For example, 2016, 11 monk seal hookings were documented. Each hooking was classified as non-serious injuries, although six would have been deemed serious had they not been mitigated. In the Northwest Hawaiian Islands, an estimated 52 tons of derelict fishing gear accumulate annually (Dameron et al. 2007). Due to this, several hundred cases of debris entanglement have been documented in monk seals (nearly all in the Northwest Hawaiian Islands), including nine documented mortalities (Carretta et al. 2019).

Cetaceans are prone to bycatch in longline, trawl and purse seine fisheries, and large whales are prone to entanglement in trap or pot fisheries. Entanglement may also make whales more vulnerable to additional dangers, such as predation and ship strikes, by restricting agility and swimming speed. From 1924 to 2015, there were 300 gray whale mortalities or serious injury events reported in the North Pacific Ocean, most (78.3 percent) were the result of fisheries interactions (Wilkinson et al. 2017).

Large whale mortalities and serious injuries related to fisheries interactions occur throughout the U.S. waters of the Pacific Ocean. Between 2011 and 2015, records of 170 large whale human-caused injury or mortality were reported on the U.S. Pacific West Coast; 124 of these incidents involved entanglement in fishing gear (Carretta et al. 2017). Humpback whales and gray whales were the most common species reported (71 and 63 individuals, respectively), but fin, sei, blue, and sperm whales were also affected (15 individuals total over that same time period) (Carretta et al. 2017). Longline fishery interactions pose a threat to Main Hawaiian Island insular false killer whales (Baird et al. 2015). Undocumented moralities and serious injuries for these and other marine mammals found within the action areas have likely occurred.

Fishery interaction remains a major facet in sea turtle recovery. Wallace et al. (2010b) estimated that worldwide, 447,000 sea turtles are killed each year from bycatch in commercial fisheries. NMFS (2002a) estimated that 62,000 loggerhead turtles have been killed as a result of incidental capture and drowning in shrimp trawl gear. It is likely that the majority of individual sea turtles and marine mammals that are killed by commercial fishing gear are never detected, making it very difficult to accurately determine the number and frequency of mortalities. Although sea

turtle excluder devices and other bycatch reduction devices have significantly reduced the level of bycatch to sea turtles and other marine species in U.S. waters, mortality still occurs.

In addition to fish capture, aquaculture has the potential to impact protected species via entanglement and/or other interaction with aquaculture gear (i.e., buoys, nets, and lines), introduction or transfer of pathogens, increased vessel traffic, impacts to habitat and benthic organisms, and water quality (NMFS 2015e; NOAA 2017).

Fisheries can have a profound influence on fish populations. In a study of retrospective data, Jackson et al. (2001) analyzed paleoecological records of marine sediments from 125,000 years ago to present, archaeological records from 10,000 years before the present, historical documents, and ecological records from scientific literature sources over the past century. Examining this long-term data and information, Jackson et al. (2001) concluded that ecological extinction caused by overfishing precedes all other pervasive human disturbance of coastal ecosystems, including pollution and anthropogenic climatic change. Fisheries bycatch has been identified as a primary driver of population declines in several groups of marine species, including sharks, mammals, marine birds, and sea turtles (Wallace et al. 2010a). Marine mammals are known to feed on several species of fish that are harvested by humans (Waring et al. 2008). Thus, competition with humans for prey is also a potential concern. Reductions in fish populations, whether natural or human-caused, may affect the survival and recovery of several populations, including those located within the action area.

7.7 Aquaculture

Marine aquaculture systems are diverse, ranging from highly controlled land-based systems to open water cages that release wastes directly into the environment. Species produced in the marine environment are also diverse, and include seaweeds, bivalve molluscs, echinoderms, crustaceans, and finfish (Langan 2004). Production from global aquaculture (including aquatic plants) was 110.2 million metric tons in 2016, with the first-sale value projected at USD 243.5 billion (FAO 2018). Aquaculture supplies more than 50 percent of all seafood produced for human consumption globally (National Oceanic and Atmospheric Administration [NOAA] Marine Aquaculture website https://www.fisheries.noaa.gov/topic/aquaculture). Marine aquaculture is expected to expand in the U. S. EEZ due to increased demand for domestically grown seafood, coupled with improved technological capacity to farm in the open ocean.

Farming the sea is a part of Hawaii's rich oceanic heritage and the state has been at the forefront of aquaculture research and technology (HDOA 2018). Hawaii is the first state to successfully operate commercial open ocean aquaculture cages in the U.S. In 2011, Hawaii's total aquaculture sales were valued at $40 million, an increase from $10 million in 2010. Algae sales accounted for 63 percent of the value, ornamental category six percent, finfish four percent, shellfish one percent, with the remaining 26 percent from sales of seedstock, broodstock and fingerlings.

Asia has accounted for about 89 percent of world aquaculture production for over two decades (FAO 2018). Overall, the top four countries with the highest global farmed fish production

contain EEZs within the action area for SURTASS LFA sonar training and testing activities. These four countries include China, India, Indonesia, and Vietnam (See Figure 34). China has produced more farmed food fish than the rest of the world combined every year since 1991.

Figure 34 Total Aquaculture Farmed Fish Production by Region and Major Producing Countries (FAO 2018)

Region/selected countries	1995	2000	2005	2010	2015	2016
Africa	110	400	646	1 286	1 772	1 982
	0.5%	*1.2%*	*1.5%*	*2.2%*	*2.3%*	*2.5%*
Egypt	72	340	540	920	1 175	1 371
	0.3%	*1.1%*	*1.2%*	*1.6%*	*1.5%*	*1.7%*
Northern Africa, excluding Egypt	4	5	7	10	21	23
	0%	*0%*	*0%*	*0%*	*0%*	*0%*
Nigeria	17	26	56	201	317	307
	0.1%	*0.1%*	*0.1%*	*0.3%*	*0.4%*	*0.4%*
Sub-Saharan Africa, excluding Nigeria	17	29	43	156	259	281
	0.1%	*0.1%*	*0.1%*	*0.3%*	*0.3%*	*0.4%*
Americas	920	1 423	2 177	2 514	3 274	3 348
	3.8%	*4.4%*	*4.9%*	*4.3%*	*4.3%*	*4.2%*
Chile	157	392	724	701	1 046	1 035
	0.6%	*1.2%*	*1.6%*	*1.2%*	*1.4%*	*1.3%*
Rest of Latin America and the Caribbean	284	447	785	1 154	1 615	1 667
	1.2%	*1.4%*	*1.8%*	*2.0%*	*2.1%*	*2.1%*
North America	479	585	669	659	613	645
	2.0%	*1.8%*	*1.5%*	*1.1%*	*0.8%*	*0.8%*
Asia	21 678	28 423	39 188	52 452	67 881	71 546
	88.9%	*87.7%*	*88.5%*	*89.0%*	*89.3%*	*89.4%*
China (mainland)	15 856	21 522	28 121	36 734	47 053	49 244
	65.0%	*66.4%*	*63.5%*	*62.3%*	*61.9%*	*61.5%*
India	1 659	1 943	2 967	3 786	5 260	5 700
	6.8%	*6.0%*	*6.7%*	*6.4%*	*6.9%*	*7.1%*
Indonesia	641	789	1 197	2 305	4 343	4 950
	2.6%	*2.4%*	*2.7%*	*3.9%*	*5.7%*	*6.2%*
Viet Nam	381	499	1 437	2 683	3 438	3 625
	1.6%	*1.5%*	*3.2%*	*4.6%*	*4.5%*	*4.5%*
Bangladesh	317	657	882	1 309	2 060	2 204
	1.3%	*2.0%*	*2.0%*	*2.2%*	*2.7%*	*2.8%*
Rest of Asia	2 824	3 014	4 584	5 636	5 726	5 824
	11.6%	*9.3%*	*10.4%*	*9.6%*	*7.5%*	*7.3%*
Europe	1 581	2 051	2 135	2 523	2 941	2 945
	6.5%	*6.3%*	*4.8%*	*4.3%*	*3.9%*	*3.7%*
Norway	278	491	662	1 020	1 381	1 326
	1.1%	*1.5%*	*1.5%*	*1.7%*	*1.8%*	*1.7%*
EU-28	1 183	1 403	1 272	1 263	1 264	1 292
	4.9%	*4.3%*	*2.9%*	*2.1%*	*1.7%*	*1.6%*
Rest of Europe	121	157	201	240	297	327
	0.5%	*0.5%*	*0.5%*	*0.4%*	*0.4%*	*0.4%*
Oceania	94	122	152	187	186	210
	0.4%	*0.4%*	*0.3%*	*0.3%*	*0.2%*	*0.3%*
World	**24 383**	**32 418**	**44 298**	**58 962**	**76 054**	**80 031**

Open-ocean aquaculture encompasses a variety of infrastructure designs; in the U.S., submersible cages are the model used for offshore finfish production (Naylor 2006). Aquaculture

cages are anchored to the sea floor but can be moved within the water column. Cages are tethered to buoys that contain an equipment room and feeding mechanism and can be large enough to hold hundreds of thousands of fish in a single cage. One of the negative effects attributed to finfish culture is enrichment of the water column with dissolved nutrients, resulting from the decomposition of uneaten feed, and from metabolic wastes produced by the fish (Langan 2004). There is growing interest in marine aquaculture systems that combine fed aquaculture species (e.g. finfish), with inorganic extractive aquaculture species (e.g. seaweeds) and organic extractive species (e.g. suspension- and deposit-feeders) cultivated in proximity to mitigate these negative effects. One type of offshore aquaculture system that is expected to grow is longline mussel aquaculture (Price et al. 2016). Aquaculture companies in Hawaii have also been experimenting with drifting, unanchored cages for open ocean fish production. In China,

The growth of the aquaculture industry has drawn attention to the potential environmental impacts of offshore aquaculture, including impacts to protected species. Although aquaculture has the potential to relieve pressure on ocean fisheries, it can also threaten marine ecosystems through the introduction of exotic species and pathogens, effluent discharge, the use of wild fish to feed farmed fish, and habitat destruction. Marine aquaculture operations have the potential to displace marine mammals from their foraging habitats or cause other disruptions to their behavior (Markowitz et al. 2004).

7.8 Whaling

Large whale population numbers in the action area have historically been impacted by aboriginal hunting and commercial exploitation, mainly in the form of whaling. From 1864 through 1985, at least 2,400,000 baleen whales (excluding minke whales) and sperm whales were killed (Gambell 1999). Modern commercial whaling removed approximately 50,000 whales annually. Prior to current prohibitions on whaling, such as the International Whaling Commission's 1966 moratorium, most large whale species were significantly depleted to the extent it was necessary to list them as endangered under the Endangered Species Preservation Act of 1966. In 1982, the International Whaling Commission issued a moratorium on commercial whaling, which began being instituted in 1986. There is currently no legal commercial whaling by International Whaling Commission Member Nations party to the moratorium; however, whales are still killed commercially by countries that filed objections to the moratorium (i.e., Iceland and Norway). Presently three types of whaling take place: (1) aboriginal subsistence whaling to support the needs of indigenous people; (2) special permit whaling; and (3) commercial whaling conducted either under objection or reservation to the moratorium. The reported catch and catch limits of large whale species from aboriginal subsistence whaling, special permit whaling, and commercial whaling can be found on the International Whaling Commission's website at: https://iwc.int/whaling. Additionally, the Japanese whaling fleet carries out whale hunts under the guise of "scientific research," though very few peer-reviewed papers have been published as a result of the program, and meat from the whales killed under the program is processed and sold at fish markets.

Norway and Iceland take whales commercially at present, either under objection to the moratorium decision or under reservation to it. These countries establish their own catch limits but must provide information on those catches and associated scientific data to the International Whaling Commission. The Russian Federation has also registered an objection to the moratorium decision but does not exercise it. The moratorium is binding on all other members of the International Whaling Commission. Norway takes minke whales in the North Atlantic Ocean within its Exclusive Economic Zone, and Iceland takes minke whales and fin whales in the North Atlantic Ocean, within its Exclusive Economic Zone (IWC 2012).

Under current International Whaling Commission regulations, aboriginal subsistence whaling is permitted for Denmark (Greenland, fin and minke whales), the Russian Federation (Siberia, gray and bowhead whales), St. Vincent and the Grenadines (Bequia, humpback whales) and the U.S. (Alaska, bowhead and gray whales). It is the responsibility of national governments to provide the International Whaling Commission with evidence of the cultural and subsistence needs of their people. The Scientific Committee provides scientific advice on safe catch limits for such stocks (IWC 2012). Based on the information on need and scientific advice, the International Whaling Commission then sets catch limits, recently in five-year blocks.

Scientific permit whaling has been done by Japan and Iceland. Japan has issued scientific permits in the Antarctic and in the western North Pacific Ocean every year in recent years targeting Bryde's whales, fin whales, humpback whales, minke whales, and sperm whales.

In Iceland, the stated overall objective of the research program was to increase understanding of the biology and feeding ecology of important cetacean species in Icelandic waters for improved management of living marine resources based on an ecosystem approach. While Iceland stated that its program was intended to strengthen the basis for conservation and sustainable use of cetaceans, it noted that it was equally intended to form a contribution to multi-species management of living resources in Icelandic waters.

Many of the whaling numbers reported represent minimum catches, as illegal or underreported catches are not included. For example, recently uncovered Union of Soviet Socialists Republics catch records indicate extensive illegal whaling activity between 1948 and 1979 (Ivashchenko et al. 2014). Additionally, despite the moratorium on large-scale commercial whaling, catch of some of these species still occurs in the Atlantic and Pacific Ocean whether it be under objection of the International Whaling Commission, for aboriginal subsistence purposes, or under International Whaling Commission scientific permit 1985 through 2013. Some of the whales killed in these fisheries are likely part of the same population of whales occurring within the action area for this consultation.

Historically, commercial whaling caused all of the large whale species to decline to the point where they faced extinction risks high enough to list them as endangered species. Since the end of large-scale commercial whaling, the primary threat to these species has been eliminated. However, as described in greater detail in the *Status of Endangered Species Act-Listed Resources* section of this opinion, all whale species have not recovered from those historic declines.

Scientists cannot determine if those initial declines continue to influence current populations of most large whale species in the Atlantic, Indian, and Pacific Oceans. For example, the North Atlantic right whale, North Pacific right whale, and Western North Pacific population of gray whale have not recovered from the effects of commercial whaling and continue to face very high risks of extinction because of their small population sizes and low population growth rates. In contrast, populations of species such as the humpback whale and Eastern North Pacific population of gray whale has increased substantially from post-whaling population levels and appear to be recovering despite the impacts of ship strikes, interactions with fishing gear, and increased levels of ambient sound in the Atlantic, Indian, and Pacific Oceans.

7.9 Sealing

Seals and sea lions have been hunted by humans for centuries for their fur, meat, and oil. One species in the action area species (Japanese sea lion [*Zalophus japonicus*]) was hunted to extinction in the 20th century, while other species were hunted to near extinction (including the Hawaiian monk seal), and many species were severely depleted. While hunting was previously the primary cause of population decline among ESA-listed pinnipeds, it no longer represents a major threat. Hunting of Hawaiian monk seals is illegal, while limited subsistence hunting of Steller sea lions and spotted seals is permitted.

7.10 Sea Turtle Harvest

Directed harvest of sea turtles and their eggs for food and other products has existed for years and was a significant factor causing the decline of green, hawksbill, leatherback, loggerhead, and olive ridley turtles. At present, despite conservation efforts such as bans and moratoriums by the responsible governments, the harvest of sea turtles and their eggs still occurs in many locations throughout the action area. Countries including Mexico, Peru, and the Philippines have made attempts to reduce the threats to sea turtles, but illegal harvesting still occurs. In some countries (e.g., Vietnam and Fiji), harvest of sea turtle meat and eggs remains unregulated.

7.11 Scientific Research

Regulations for section 10(a)(1)(A) of the ESA allow issuance of permits authorizing take of certain ESA-listed species for the purposes of scientific research. Prior to the issuance of such a permit, the proposal must be reviewed for compliance with section 7 of the ESA. Scientific research permits issued by NMFS currently authorize studies on ESA-listed species in the Indian and Pacific Oceans, some of which occur in portions of the action area. Marine mammals and sea turtles have been the subject of field studies for decades. The primary objective of most of these field studies has generally been monitoring populations or gathering data for behavioral and ecological studies. Over time, NMFS has issued dozens of permits on an annual basis for various forms of “take” of marine mammals and sea turtles in the action area from a variety of research activities.

Authorized research on ESA-listed whales and dolphins includes close vessel and aerial approaches, photographic identification, photogrammetry, biopsy sampling, tagging, ultrasound,

exposure to acoustic activities, breath sampling, behavioral observations, passive acoustic recording, and underwater observation. Research activities involve non-lethal "takes" of these whales and dolphins.

ESA-listed pinniped research includes approach, capture, handling, restraint, biopsy, nail clip, blood and tissue sampling, anesthesia, temporary captivity, tagging, translocation, swab sampling, lavage, hot branding, tooth extraction, ultrasound, and mortality. Most research involves sub-lethal take (e.g., capture and release), but unintentional and intentional mortalities were permitted annually. Lethal take of male Hawaiian monk seals has been authorized in specific instances of mobbing. The removal of specific males involved in mobbing preserves the health of female and young individuals that will provide greater contributions to the survival and recovery of the species. For Western DPS of Steller sea lions and Southern DPS of spotted seals, most authorized take is sub-lethal (e.g., capture and release), but some unintentional mortalities are authorized annually.

ESA-listed sea turtle research includes approach, capture, handling, restraint, tagging, biopsy, blood or tissue sampling, lavage, ultrasound, imaging, antibiotic (tetracycline) injections, laparoscopy, captive experiments, and mortality. Most authorized take is sub-lethal with some resulting in mortality.

7.12 Vessel Strike

Ships have the potential to affect animals through strikes, noise, and disturbance by their physical presence. Vessel strike is a significant and widespread concern for the recovery of ESA-listed marine mammals and sea turtles. This threat is increasing as commercial shipping lanes cross important breeding and feeding habitats and as whale populations recover and populate new areas or areas where they were previously extirpated (Swingle et al. 1993; Wiley et al. 1995). As ships continue to become faster and more widespread, an increase in vessel interactions with marine mammals is expected. All sizes and types of vessels can hit whales, but most lethal and severe injuries are caused by ships 80 m (262.5 ft) or longer. For whales, studies show that the probability of fatal injuries from ship strikes increases as vessels operate at speeds above 26 kph (14 kt) (Laist et al. 2001). Evidence suggests that not all whales killed as a result of vessel strike are detected, particularly in offshore waters, and some detected carcasses are never recovered while those that are recovered may be in advanced stages of decomposition that preclude a definitive cause of death determination (Glass et al. 2010). Most whales killed by vessel strike likely end up sinking rather than washing up on shore, and it is estimated that 17 percent of vessel strikes are actually detected (Kraus et al. 2005). Therefore, it is likely that the number of documented cetacean mortalities related to vessel strikes is much lower than the actual number of mortalities associated with vessel strikes. It should be noted that, unlike other maritime entities, the Navy has a policy to report all vessel strikes.

Of the eleven species known to be hit by ships, fin whales are stuck most frequently, and right whales, humpback whales, sperm whales, and gray whales are also hit commonly (Laist et al. 2001; Vanderlaan and Taggart 2007). In some areas, one-third of all fin whale and right whale

strandings appear to involve vessel strikes (Laist et al. 2001). The effects of vessel strikes are particularly profound on species with low abundance.

7.13 Vessel Approaches – Commercial and Private Marine Mammal Watching

Whale watching is a rapidly growing business with more than 3,300 operators worldwide, serving 13 million participants in 119 countries and territories (O'connor et al. 2009). As of 2010, commercial whale watching was a one billion dollar global industry per year (Lambert et al. 2010). Private vessels may partake in this activity as well. NMFS has issued certain regulations and guidelines relevant to whale watching. As noted previously, many of the cetaceans considered in this opinion are highly migratory, so may also be exposed to whale watching activity occurring outside of the action area.

Although considered by many to be a non-consumptive use of marine mammals with economic, recreational, educational and scientific benefits, marine mammal watching is not without potential negative impacts. Whale watching has the potential to harass whales by altering feeding, breeding, and social behavior or even injure them if the vessel gets too close or strikes the whale. Preferred habitats may be abandoned if disturbance levels are too high. Animals may also become more vulnerable to vessel strikes if they habituate to vessel traffic (Swingle et al. 1993; Wiley et al. 1995).

Several studies have examined the short-term effects of whale watch vessels on marine mammals (Watkins 1986a; Corkeron 1995; Au and Green 2000a; Felix 2001; Erbe 2002b; Magalhaes et al. 2002; Williams et al. 2002c; Richter et al. 2003a; Scheidat et al. 2004; Amaral and Carlson 2005; Simmonds 2005). The whale's behavioral responses to whale watching vessels depended on the distance of the vessel from the whale, vessel speed, vessel direction, vessel noise, and the number of vessels. In some circumstances, the whales did not respond to the vessels, but in other circumstances, whales changed their vocalizations, surface time, swimming speed, swimming angle or direction, respiration rates, dive times, feeding behavior, and social interactions. Sullivan and Torres (2018) tracked gray whales and vessels in summer 2015 using non-invasive, shore-based theodolite and photo identification techniques. During their study, the team documented significant differences in gray whale activity budgets between control and impact conditions, and between study sites. However they did not observe significant differences in individual responses to vessel disturbance (Sullivan and Torres 2018). Disturbance by whale watch vessels has also been noted to cause newborn calves to separate briefly from their mother's side, which leads to greater energy expenditures by the calves (NMFS 2006b)

Although numerous short-term behavioral responses to whale watching vessels are documented, little information is available on whether long-term negative effects result from whale watching (NMFS 2006a). Christiansen et al. (2014) estimated the cumulative time minke whales spent with whale watching boats in Iceland to assess the biological significance of whale watching disturbances and found that, though some whales were repeatedly exposed to whale watching boats throughout the feeding season, the estimated cumulative time they spent with boats was

very low. Christiansen et al. (2014) suggested that the whale watching industry, in its current state, is likely not having any long-term negative effects on vital rates.

It is difficult to precisely quantify or estimate the magnitude of the risks posed to marine mammals in general from vessel approaches. Given the SURTASS LFA sonar sound fields greater than 180 dB re: 1 µPa (rms) will not occur in areas with 22 km (12 nmi) of land, few whale watching boats would be expected to co-occur with the SURTASS LFA sonar vessels in the action area.

Vessel strikes are a poorly-studied threat to sea turtles, but have the potential to be highly significant (Work et al. 2010). All sea turtles must surface to breathe and several species are known to bask at the surface for long periods, including loggerhead turtles. Although sea turtles can move somewhat rapidly, they apparently are not adept at avoiding vessels that are moving at more than 4 km (2.2 nmi) per hour; most vessels move far faster than this in open water (Hazel and Gyuris 2006; Hazel et al. 2007; Work et al. 2010). Both live and dead sea turtles are often found with deep cuts and fractures indicative of collision with a boat hull or propeller (Hazel et al. 2007). Hazel et al. (2007) suggested that green turtles may use auditory cues to react to approaching vessels rather than visual cues, making them more susceptible to strike as vessel speed increases.

7.14 Conservation Management Efforts

Several conservation and management efforts have been undertaken for marine mammals and sea turtles in the action area. Recovery plans guide the protection and conservation of these species (NMFS 1991b). NMFS implements conservation and management activities for the species through its regional offices and fishery science centers in cooperation with states, conservation groups, the public, and other federal agencies. A non-exhaustive list of conservation and management actions are below:

- Observers are placed aboard some fishing vessels and vessels engaged in seismic surveys to record and monitor impacts to protected species.
- Take reduction plans have required acoustic pingers to help repel marine mammals from fishing operations.
- NMFS mitigates vessel strikes and responds to whales in distress.
- Together with their partners, NMFS educates the crew of whale watch vessels and other boat operators on safe boating practices.
- NMFS has implemented a series of regulations aimed at reducing potential for incidental mortality of sea turtles from commercial fisheries in the action area.
- NMFS oversees an extensive network of Sea Turtle Stranding and Salvage Network participants along the Atlantic and Gulf of Mexico coasts who not only collect data on dead sea turtles, but also rescue and rehabilitate any live stranded sea turtles.

Conservation and management efforts for marine mammals and sea turtles are also implemented independent of NMFS. For example, and most notably for cetaceans, in 1946, the International

Convention for the Regulation of Whaling began regulating commercial whaling and in 1966, the International Whaling Commission prohibited commercial whaling.

7.15 Underwater Sound

The ESA-listed species that occur in the action area are regularly exposed to several sources of natural and anthropogenic sounds. Natural sounds include wind and waves, precipitation, seismic phenomena, and biological sounds (e.g., from marine mammals, invertebrates, soniferous fishes). Anthropogenic noises include, but are not limited to, maritime activities, dredging, construction; mineral exploration in offshore areas; geophysical (seismic) surveys; sonars; explosions; and ocean research activities. Ambient noise is the background level of sound in the environment and is caused by naturally-occurring physical and biological sources as well as anthropogenic sources. Ambient noise levels are higher in the northern hemisphere, where sources of anthropogenic sounds are more pervasive. However, even in relatively quiet regions in the southern hemisphere, ambient noise levels commonly vary by 20 dB and will vary by 30 dB with lower frequency because of biological sources and sea surface noise (Cato and McCauley. 2001). Below, we discuss both natural and anthropogenic noise sources that collectively contribute to the total noise at any one place and time in the action area. ESA-listed species have the potential to be impacted by either increased levels of anthropogenic-induced background noise or high intensity, short-term sounds.

7.15.1 Natural Sources

There are numerous natural sources of noise that have low frequencies that are comparable to SURTASS LFA sonar, such as:

Wind and waves. Wind and waves are common and interrelated sources of ambient noise in all of the world's oceans. All other factors being equal, ambient noise levels tend to increase with increasing wind speeds and wave height (Richardson et al. 1995g). Noise generated by surface wave activity is one of the two primary contributors to ambient noise in the frequency range from 300 Hz to 5 kHz. The wind-generated noise level decreases smoothly with increasing acoustic frequency (i.e., there are no spikes at any given frequency).

Precipitation. At some frequencies, rain and hail will increase ambient noise levels. Significant noise is produced by rain squalls over a range of frequencies from 500 Hz to 15 kHz. Large storms with heavy precipitation can generate noise at frequencies as low as 100 Hz and significantly affect ambient noise levels at a considerable distance from a storm's center. Lightning strikes associated with storms are loud, explosive events that deliver an average of 100 kiloJoules per meter of energy (Considine 1995). Hill (1985) estimated that SLs for cloud-to-water pulse to be 260.5 dB. It has been estimated that over the earth's oceans the frequency of lightning averages about ten flashes per second, or 314 million strikes per year (Kraght 1995).

Seismic Phenomena. Underwater volcanic eruptions, earthquakes, and landslides produce sound in the frequency range of 1 to 100 Hz. In the Pacific Ocean, where the majority of seismic activity occurs in the world's oceans, about 10,000 natural, seismic phenomena occur each year

(Fox et al. 2001). Hill (1985) stated that these phenomena produce sounds with SLs exceeding 255 dB re: 1 µPa (rms) at 1 m.

Biological Noise. Sounds created by animals in the sea and may contribute significantly to ambient noise in many areas of the oceans (Curtis et al. 1999). Because of the habits, distribution, and acoustic characteristics of these sound producers, certain areas of the oceans are louder than others. Only three groups of marine animals are known to make sounds: crustaceans (such as snapping shrimp), fishes, and marine mammals (Urick 1983). The most widespread, broadband noises from animal sources (in shallow water) are those produced by croakers (representative of a variety of fish classified as drumfish) (100 Hz to 10 kHz) and snapping shrimp (500 Hz to 20 kHz). Sound-producing fishes and crustaceans are restricted almost entirely to bays, reefs, and other coastal waters, although there are some pelagic, sound-producing fish. In oceanic waters, whales and other marine mammals are principal contributors to biological noise. For example, dolphins produce whistles associated with certain behaviors, and the baleen whales are noted for their low frequency vocalizations.

7.15.2 Anthropogenic Sources

Anthropogenic noise is generated by commercial and recreational vessels, aircraft, military activities, seismic surveys, in-water construction activities, and other human activities. These activities all occur within the action area to varying degrees throughout the year. The scientific community recognizes the addition of anthropogenic sound to the marine environment as a stressor that could possibly harm marine animals or significantly interfere with their normal activities (NRC 2005a). The species considered in this opinion may be impacted by anthropogenic noise in various ways. Once detected, some sounds may produce a behavioral response, including but not limited to changes in habitat to avoid areas of higher noise levels, changes in diving behavior, or changes in vocalization (MMC 2007).

Many researchers have described behavioral responses of marine mammals to the sounds produced by boats and ships, as well as other noise sources such as helicopters and fixed-wing aircraft, and dredging and construction. Most observations have been limited to short-term behavioral responses, which included temporary cessation of feeding, resting, or social interactions; however, habitat abandonment can lead to more long-term effects which may have implications at the population level. Masking may also occur, in which an animal may not be able to detect, interpret, and/or respond to biologically relevant sounds. Masking can reduce the range of communication, particularly long-range communication, such as that for blue and fin whales. This could have a variety of implications for an animal's fitness including, but not limited to, predator avoidance and the ability to reproduce successfully (MMC 2007). Scientific evidence suggests that marine mammals, including blue and fin whales, compensate for masking by changing the frequency, SL, redundancy, or timing of their signals, but the long-term implications of these adjustments are currently unknown (Parks 2003; Mcdonald et al. 2006a; Parks 2009b).

In the action area, seismic activity for oil and gas exploration has occurred. This has included a 3D seismic survey in the South China Sea, multiple 3D and 2D seismic surveys off the northwest coast of Australia, and several 2D seismic surveys off the coast of Samatra (TGS 2019). ESA-listed cetaceans are expected to exhibit a wide range of behavioral responses as a consequence of being exposed to seismic air gun sound fields and echosounders. Baleen whales are expected to mostly exhibit avoidance behavior, and may also alter their vocalizations. Sperm whales are expected to exhibit less overt behavioral changes, but may alter foraging behavior, including vocalizations. These responses are expected to be temporary with behavior returning to a baseline state shortly after the seismic source becomes inactive or leaves the area. Individual whales exposed to sound fields generated by seismic air guns could also exhibit responses not readily observable, such as stress (Romano et al. 2002), that may have adverse effects. Other possible responses to impulsive sound sources like seismic air guns include neurological effects, bubble formation, resonance effects, and other types of organ or tissue damage (Cox et al. 2006; Southall et al. 2007c; Zimmer and Tyack 2007; Tal et al. 2015), but similar to stress, these effects are not readily observable.

As with cetaceans, ESA-listed sea turtles may exhibit a variety of different responses to sound fields associated with seismic air guns and echosounders. Avoidance behavior and physiological responses from air gun exposure may affect the natural behaviors of sea turtles (McCauley et al. 2000a). McCauley et al. (2000a) conducted trials with caged sea turtles and an approaching-departing single air gun to gauge behavioral responses of green and loggerhead sea turtles. Their findings showed behavioral responses to an approaching air gun array at 166 dB re: 1 µPa (rms) and avoidance around 175 dB re: 1 µPa (rms). From measurements of a seismic vessel operating 3-dimensional air gun arrays in 100 to 120 m water depth this corresponds to behavioral changes at around two kilometers and avoidance around one kilometer.

Despite the potential for these impacts to affect individual ESA-listed marine species, information is not currently available to determine the potential population level effects of anthropogenic sound levels in the marine environment (MMC 2007) , nor the degree this affects ESA-listed species within the action area. More information would be required including, but not limited to, empirical data on how sound impacts an individual's growth and vital rates, how these changes impact that individual's ability to reproduce successfully, and then the relative influence of that individual's reproductive success on the population being considered. As a result, the consequences of anthropogenic sound on threatened and endangered marine species in the action area remain uncertain.

7.15.2.1 *Vessel Noise and Commercial Shipping*

Vessel noise produced from commercial shipping traffic is a major source of low frequency anthropogenic sound in the action area (NRC 2003a) (Figure 35). Large vessels emit predominantly low frequency sound which overlaps with many mysticetes predicted hearing ranges (7 Hz to 35 kHz) (NOAA 2016) and may mask their vocalizations and cause stress (Rolland et al. 2012). Studies also report broadband sound from large cargo ships above 2 kHz that may interfere with important biological functions of odontocetes, including foraging (Holt

2008; Blair et al. 2016). Other commercial vessels (e.g., whale watching, fisheries, etc.) and recreational vessels also operate within the action area and may produce similar sounds, although to a lesser extent given their much small size. Anthropogenic sound from vessel traffic may be particularly prevalent in shallower waters (13 to 19 m [42.7 to 62.3 ft]). At greater foraging depths of 100 to 200 m (328.1 to 656.2 ft) (Croll et al. 2001a; Goldbogen et al. 2011), less but still substantial vessel traffic sound can be heard. Anthropogenic noise from vessel traffic within the action area can be seen in Figure 35 below.

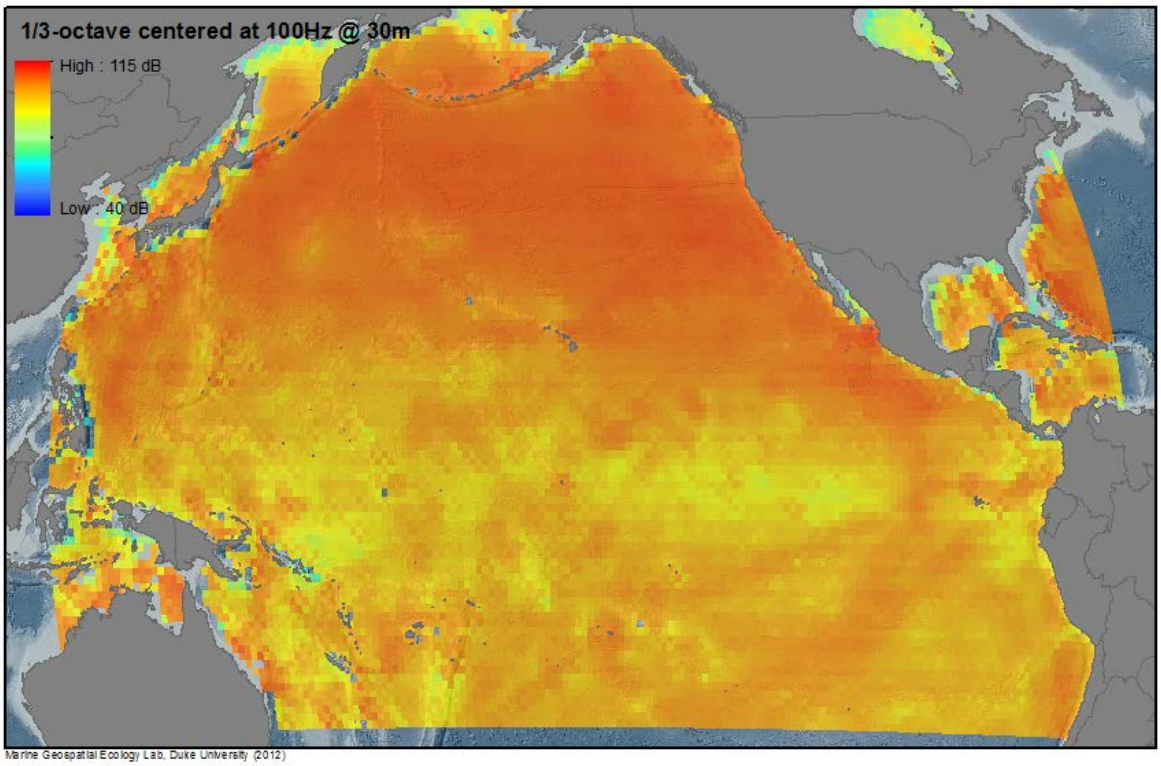

Figure 35. Vessel traffic sound in decibels, 1/3-octave centered at 100 Hertz at 30 m, within the Pacific Ocean. Data from http://cetsound.noaa.gov.

Individual vessels produce unique acoustic signatures, although these signatures may change with ship speed, vessel load, and activities that may be taking place on the vessel. Peak spectral levels for individual commercial ships are in the frequency band of ten to 50 Hz and range from 195 dB re: $\mu Pa^2/Hz$ at 1 m for fast-moving (greater than 20 kt) supertankers to 140 dB re: $\mu Pa^2/Hz$ at 1 m for small fishing vessels (NRC 2003b). Small boats with outboard or inboard engines produce sound that is generally highest in the mid-frequency (one to five kHz) range and at moderate (150 to 180 dB re: 1 µPa at 1 m) SLs (Erbe 2002b; Gabriele et al. 2003; Kipple and Gabriele 2004). On average, noise levels are higher for the larger vessels, and increased vessel speeds resulted in higher noise levels.

Measurements made over the period 1950 through 1970 indicated low frequency (50 Hz) ship traffic noise in the eastern North Pacific was increasing by 0.55 dB per year. Data obtained in the northeast Pacific from 1978 to 1986 suggest the 0.55 dB per year increase seen in the early data continued to around 1980, but then slowed to about 0.2 dB per year (Chapman and Price 2011). Data obtained in the northeast Pacific Ocean from 1978 through 1986 suggest the 0.55 dB per year increase seen in the early data continued to around 1980, but then slowed to about 0.2 dB per year (Chapman and Price 2011). Hildebrand (2009) documented a three dB per decade increase in ambient noise in the 40 Hz band staring in the late 1950s (Hildebrand 2009). Similar trends were documented in the Indian Ocean with the most prominent increases in ocean noise occurring in the 85 to 105 Hz band. The authors noted that this increase was consistent with concurrent increases in shipping, wind speed, wave height, and blue whale abundance in the Indian Ocean (Miksis-Olds et al. 2013).

7.15.2.2 *Air Force Training and Testing Activities*

The Air Force conducts training and testing activities on range complexes on land and in U.S. waters. Aircraft operations and air-to-surface activities may occur in the action area (e.g., off Hawaii). Air Force activities generally involve the firing or dropping of munitions (e.g., bombs, missiles, rockets, and gunnery rounds) from aircraft towards targets located on the surface, though Air Force training exercises may also involve boats. These activities have the potential to impact ESA-listed species by physical disturbance, boat strikes, debris, ingestion, and effects from noise and pressure produced by detonations. Air Force training and testing activities constitute a federal action and take of ESA-listed species considered for these Air Force activities have previously undergone separate section 7 consultation.

7.15.2.3 *Navy Range Complex Training and Testing Activities*

The Navy conducts training, testing, and other military readiness activities on range complexes throughout coastal and offshore areas in the U.S. and on the high seas. Navy range activities conducted near and within the action area occur off areas such as the coast of Hawaii and the Mariana Islands (NMFS 2015c; NMFS 2018c). During training, existing and established weapon systems and tactics are used in realistic situations to simulate and prepare for combat. Activities include: routine gunnery, missile, surface fire support, amphibious assault and landing, bombing, sinking, torpedo, tracking, and mine exercises. Testing activities are conducted for different purposes and include: at-sea research, development, evaluation, and experimentation. The Navy performs testing activities to ensure that its military forces have the latest technologies and techniques available to them. The majority of the training and testing activities the Navy conducts in the action area are similar, if not identical, to activities that have been occurring in the same locations for decades. Additionally, SURTASS LFA sonar vessels may participate in joint major training events.

Navy activities produce sound and visual disturbances to marine mammals throughout the action area (NMFS 2015c; NMFS 2018c). The Navy training and testing activities constitute a federal action and take of ESA-listed marine mammals and sea turtles considered for these Navy

activities have previously undergone separate section 7 consultation (NMFS 2015c; NMFS 2018c).

7.15.2.4 *Navy Active Sonar Routine Training, Testing, and Military Operations*

SURTASS LFA sonar is a coherent low frequency signal with a duty cycle of less than 20 percent, which is proposed to operate for a maximum of 496 hours of SURTASS LFA sonar transmissions in years 2019 to 2023 and 592 hours in years 2024 to 2026, and into the reasonably foreseeable future for all SURTASS LFA sonar vessels (Past years set a maximum of 255 hours annually per vessel in the past). This compares to an approximate 21.9 million days per year for the world's shipping industry (presuming an 80 percent activity rate all the time). Thus, SURTASS LFA sonar transmissions would make up a very small part of the human-caused noise pollution in the action area.

The information below is a summary of quarterly and annual mission reports provided by the Navy as a requirement of previous ESA section 7 consultations and MMPA Incidental Take Authorizations. Past operation of SURTASS LFA sonar in the western and central North Pacific Ocean and the globe over the 17 plus year period spanning from 2002 through the beginning of 2019 involved 195 completed missions conducted in slightly over 628 days during which LFA sonar was transmitted for a total of approximately 1267 hours (Table 13). During those missions, 29 marine mammals or sea turtles were visually observed, 11 marine animals were detected passive acoustically, and 190 marine animals were detected active-acoustically by the HF/M3 active sonar system. These combined detections of marine animals led to 282 suspensions/delays of LFA sonar transmissions, per the mitigation protocol for the operation of SURTASS LFA sonar. For more information on specific years, see Table 13.

Table 13. Summary of Surveillance Towed Array Sensor System (SURTASS) Low Frequency Active (LFA) sonar missions and mitigation and monitoring measure detections from 2002 through May 13, 2019.

Year[1]	Vessel	Mission Summary			Visual Detections[3]	Passive Acoustic Detections[3]	Active Acoustic HF/M3 Detections	Mitigation Protocol Suspensions/Delays
		Number	Days	LFA Sonar Hours				
2002 – 2003	R/V *Cory Chouest*	7	34.2	82.2	0	0	3	3
2003 – 2004	R/V *Cory Chouest*	5	72.5	173.7	0	0	10	10
	USNS *IMPECCABLE*	5			0	0	6	8
2004 – 2005	R/V *Cory Chouest*	3	22.5	41.9	0	0	1	12
	USNS *IMPECCABLE*	2			0	0	1	1

Year[1]	Vessel	Mission Summary			Visual Detections[3]	Passive Acoustic Detections[3]	Active Acoustic HF/M3 Detections	Mitigation Protocol Suspensions/Delays
		Number	Days	LFA Sonar Hours				
2005 – 2006	R/V *Cory Chouest*	12	95.6	173.2	1	0	47	58
	USNS *IMPECCABLE*	6			2	0	3	5
2006 – 2007	R/V *Cory Chouest*	6	94.6	161.5	0	0	30	80
	USNS *IMPECCABLE*	13			1	0	0	1
2007 – 2008	R/V *Cory Choest*	6	49.8	135.8	0	0	0	0
	USNS *IMPECCABLE*	8			1	0	19	20
2008 – 2009	USNS *ABLE*	3	23.7	32.5	1	0	1	2
	USNS *IMPECCABLE*	6			2	0	1	3
2009 – 2010	USNS *ABLE*	10	17.1	43.6	0	0	0	0
	USNS *IMPECCABLE*	21			0	3[4]	3[4]	3
2010 – 2011	USNS *ABLE*	8	62.3	64.0	0	1	0	0
	USNS *EFFECTIVE*	1			2[5]	0	2[6]	4
	USNS *IMPECCABLE*	7			0	0	2	2
2011 – 2012	USNS *ABLE*	6	44.8	101.86	0	1	1	2
	USNS *EFFECTIVE*	5			0	0	0	0
	USNS *IMPECCABLE*	3			0	0	0	0
	USNS *VICTORIOUS*	1			0	0	0	0
2012 – 2013	USNS *ABLE*	3	24.4	47.3	0	0	0	0
	USNS *EFFECTIVE*	4			0	3	9	9
	USNS *IMPECCABLE*	2			0	0	0	0
	USNS *VICTORIOUS*	3			0	0	1	1
2013 – 2014	USNS *ABLE*	3	20.44	38.63	0	0	4	4
	USNS *EFFECTIVE*	3			0	0	0	0

Year[1]	Vessel	Mission Summary			Visual Detections[3]	Passive Acoustic Detections[3]	Active Acoustic HF/M3 Detections	Mitigation Protocol Suspensions/Delays
		Number	Days	LFA Sonar Hours				
	USNS *IMPECCABLE*	0			0	0	0	0
	USNS *VICTORIOUS*	1			0	0	1	1
2014 – 2015	USNS *ABLE*	1	22.9	51.6	0	0	1	1
	USNS *EFFECTIVE*	6			5	0	5	9
	USNS *IMPECCABLE*	2			1	0	1	1
	USNS *VICTORIOUS*	1			0	0	0	0
2015 – 2016	USNS *ABLE*	3	31.1	52.6	0	0	0	0
	USNS *EFFECTIVE*	6			5	3	21	21
	USNS *IMPECCABLE*	1			0	0	0	0
	USNS *VICTORIOUS*	3			4	0	7	8
2016 – 2017	USNS *ABLE*	4	8.8	23.8	0	0	1	1
	USNS *EFFECTIVE*	1			0	0	0	0
	USNS *IMPECCABLE*	2			1	0	3	4
	USNS *VICTORIOUS*	0			0	0	0	0
2017– 2018	USNS *ABLE*	1	11.46	23.0	0	0	1	1
	USNS *EFFECTIVE*	0			0	0	0	0
	USNS *IMPECCABLE*	1			0	0	0	0
	USNS *VICTORIOUS*	1			0	0	1	1
2018– 2019(to date)	USNS *ABLE*	1	8.2	19.45	1	0	4	4
	USNS *EFFECTIVE*	1			0	0	0	0
	USNS *IMPECCABLE*	4			2	0	0	2
	USNS *VICTORIOUS*	0			0	0	0	0
	Totals	202	644.4	1,266.64	29	11	190	282

[1]August through August (excluding 2018-2019 which is August through May)
[2]LFA sonar suspended during HF/M3 non-availability
[3]Only includes visual and passive acoustic detections within the mitigation/buffer zone.
[4]Marine mammal passive contacts verified by HF/M3 sonar system within the mitigation/buffer zone.
[5]One contact confirmed with HF/M3 sonar, second was a sea turtle
[6]Only one contact confirmed visually
[7]One visual sighting of a marine mammal after the mission ended and LFA sonar was non-operational
[8]One shut-down due to loss of passive acoustics system
[9]LFA sonar suspended five times due to equipment faults
[10]Starting 2014, LFA sonar suspensions/delays for non-mitigation factors recorded. Includes HF/M3 non-availability as well as operational and equipment issues. After August 2017, reporting on these delays were discontinued.

7.16 Synthesis of Baseline Impacts

Collectively, the stressors described above have had, and likely continue to have, lasting impacts on the ESA-listed species considered in this opinion. Some of these stressors result in mortality or serious injury to individual animals (e.g., vessel strike, whaling), whereas others result in more indirect (e.g., a fishery that impacts prey availability) or non-lethal impacts (e.g., whale watching). Assessing the aggregate impacts of these stressors on the species considered in this opinion is difficult. This becomes even more difficult considering that many of the species in this opinion are wide ranging and subject to stressors in locations throughout the action area and beyond.

We consider the best indicator of the aggregate impact of the past and ongoing effects in the *Environmental Baseline* on ESA-listed resources to be the status and trends of those species. A thorough review of the status and trends of each species is discussed in the Status of Endangered Species Act-Listed Resources (Section 6) of this opinion.

As noted, some of the species considered in this opinion are experiencing increases in population abundance, some are declining, and for others, their status remains unknown. Taken together, this indicates that the *Environmental Baseline* is impacting species in different ways. The species experiencing increasing population abundances are doing so despite the potential negative impacts of the *Environmental Baseline*. Therefore, while the *Environmental Baseline* described previously may slow their recovery, recovery is not being prevented. For the species that may be declining in abundance, it is possible that the suite of conditions described in the *Environmental Baseline* is preventing their recovery. However, it is also possible that their populations are at such low levels (e.g., due to historic commercial whaling) that even when the species' primary threats are removed, the species may not be able to achieve recovery. At small population sizes, species may experience phenomena such as demographic stochasticity, inbreeding depression, and Allee effects, among others, that cause their limited population size to become a threat in and of itself.

8 EFFECTS OF THE ACTION

ESA Section 7 regulations define "effects of the action" as the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are

interrelated or interdependent with that action, that will be added to the environmental baseline (50 C.F.R. §402.02). Indirect effects are those that are caused by the proposed action and are later in time, but are reasonably certain to occur. This effects analyses section is organized following the stressor, effects, exposure, response, and risk analysis.

In this section, we further describe the potential stressors associated with the proposed action that are likely to adversely affect ESA-listed species, the probability of individuals of ESA-listed species being exposed to these stressors based on the best scientific and commercial evidence available, and the probable responses of those individuals (given probable exposures) based on the available evidence. For any responses that would be expected to reduce an individual's fitness (i.e., growth, survival, annual reproductive success, or lifetime reproductive success), the assessment would consider the risk posed to the viability of the population(s) those individuals comprise and to the ESA-listed species those populations represent. The purpose of this assessment and, ultimately, of this consultation is to determine if it is reasonable to expect the proposed action to have effects on ESA-listed species that could appreciably reduce their likelihood of surviving and recovering in the wild.

8.1 Stressors Associated with the Proposed Action

As discussed in Section 4, stressors are any physical, chemical, or biological entity that may induce an adverse response either in an ESA-listed species or their designated critical habitat. Based on a review of available information, we determined which of the possible stressors described in Section 4 will likely occur and which will be discountable or insignificant for the species and habitats affected by these activities. As stated in Section 4, noise from vessels and the HF/M3 sonar system, vessel strike, vessel discharge, and entanglement are stressors that are not likely to adversely affect ESA-listed species or critical habitat in the SURTASS LFA sonar training and testing action area. During consultation, we determined that sound fields produced by LFA sonar may adversely affect ESA-listed. This stressor and the likely effects on ESA-listed species that are likely to be adversely affected (those presented in Section 6) by SURTASS LFA sonar training and testing activities are discussed below.

8.1.1 Low Frequency Active Sonar Components

The LFA system consists of up to 18 low-frequency acoustic-transmitting projectors that are suspended from a cable beneath the ship. The SL of an individual projector in the LFA sonar array is about 215 dB re: 1 µPa (rms) at 1 m, and the sound field of the array can never have a sound pressure level higher than that of an individual projector. The typical LFA sonar signal is not a constant tone, but is a transmission of various signal types that vary in frequency and duration (including continuous wave and frequency-modulated signals). The Navy refers to a complete sequence of sound transmissions as a "ping" which can range from between six and 100 seconds, with no more than ten seconds at any single frequency. The time between pings will typically range from six to 15 minutes. The Navy can control the average duty cycle (the ratio of sound "on" time to total time) for the system but the duty cycle cannot exceed 20 percent. Based on operations since 2003, the duty cycle has averaged about 7.5 percent.

The LFA sonar mitigation zone covers a volume ensonified to a received level at or above 180 dB re: 1 µPa (rms) by the SURTASS LFA sonar transmit array. Based on spherical spreading (20logR), this zone will vary between the nominal ranges of 0.75 to one km (0.4 to 0.5 nmi) from the source array ranging over a depth of approximately 87 to 157 m (285 to 515 ft) from the array. The center of the array is at an approximate depth of 122 m (400 ft).

We assume that the propagation of signals transmitted from LFA sonar systems would be affected by surface ducts, sound channels, convergence zones, and bottom interactions. For more complete discussion of sound propagation in marine environments, readers should refer to Richardson et al. (1995g), Appendix B of the Navy EIS on SURTASS LFA sonar (Navy 2001b; Navy 2018b), and NMFS' 2002 and 2007 MMPA final rule and biological opinions on SURTASS LFA sonar. Sections 8.5 and 8.6 present our exposure and response analysis for this stressor while Section 8.7 presents our risk analysis.

8.2 Potential Effects of LFA Sonar on Marine Mammals

For marine mammals that are exposed to SURTASS LFA sonar transmission, this section examines the relationship between received levels and ecological effects; the plausibility of adverse effects occurring as a result of exposure; and linkages between measurable ecological effects and vital rates or biologically-important behavior in populations of ESA-listed marine mammals, which are the endpoints for this assessment. In this analysis we consider potential for hearing loss (PTS and TTS) behavioral changes, masking, and stranding as a result of exposure to SURTASS LFA sonar.

To assess the plausibility of adverse effects resulting from exposure to SURTASS LFA sonar, we evaluated various lines of evidence from published and unpublished sources on the effects of SURTASS LFA sonar on threatened and endangered species, other studies of low frequency sound, and reports on the effects of other sonars. We evaluate the same lines of evidence to establish linkages between the potential effects of SURTASS LFA sonar on biologically important behavior of ESA-listed species exposed to the sonar. We also consider information provided in annual and summary reports on previous SURTASS LFA sonar training and testing activities.

8.2.1 Non-Auditory Injury

Non-impulsive sources lack the rapid changes in pressure and rise times associated with impulsive sounds. Therefore, physical injuries caused by large pressure changes such as barotraumas will not occur from exposure to LFA sonar. The theories of sonar induced acoustic resonance, sonar induced bubble formation, and nitrogen decompression are discussed below. These phenomena, if they were to result, would require the co-occurrence of a precise set of circumstances that are unlikely to occur.

8.2.1.1 *Acoustic Resonance*

Physical effects, such as direct acoustic trauma or acoustically enhanced bubble growth, require relatively intense received energy that would only occur at short distances from high-powered sonar sources (Nowacek et al. 2007; Zimmer and Tyack 2007). The best available scientific information shows that, while resonance can occur in marine animals, this resonance does not necessarily cause injury, and any such injury should it occur, is not expected to occur below a received level of 180 dB re: 1 µPa (rms). Damage to the lungs and large sinus cavities of cetaceans from air space resonance is not likely to occur because resonance frequencies of marine mammal lungs are below that of the LFA sonar signal (Finneran 2003). Biological tissues in these animals are heavily damped and tissue displacement at resonance is predicted to be exceedingly small. In addition, lung tissue damage is generally uncommon in acoustic-related standings (Southall et al. 2007b).

8.2.1.2 *Bubble Formation*

A suggested cause of injury to marine mammals is rectified diffusion (Crum and Mao 1996), the process of increasing the size of a bubble by exposing it to a sound field. The process is dependent upon a number of factors including the sound pressure level and duration. Under this hypothesis, one of three things could happen: (1) bubbles grow to the extent that tissue hemorrhage (injury) occurs, (2) bubbles develop to the extent an immune response is triggered for nervous tissue is subjected to enough localized pressure that pain or dysfunction occurs (a stress response without injury), or (3) the bubbles are cleared by the lung without negative consequence to the animal. The probability of rectified diffusion, or any other indirect tissue effect, will necessarily be based upon what is known about the specific process involved. Rectified diffusion is more likely if the environment in which the ensonified bubbles exist is supersaturated with gas. Repetitive diving by marine mammals can cause the blood and some tissues to accumulate gas to a greater degree than is supported by the surrounding environmental pressure (Ridgway and Howard 1979). The dive patterns of some marine mammals (e.g., beaked whales) are theoretically predicted to induce greater supersaturation (Houser et al. 2001b; Houser 2010). If rectified diffusion were possible in marine mammals exposed to high-level sound, conditions of tissue supersaturation could theoretically speed the rate of bubble growth and increase the size of the bubbles. Subsequent effects due to tissue trauma and emboli would presumably mirror those observed in humans suffering from decompression sickness. It is unlikely the short duration of sonar exposure would be long enough to drive bubble growth to any substantial size, if such a phenomenon occurs.

An alternative but related hypothesis has also been suggested: stable microbubbles could be destabilized by high-level sound exposures such that bubble growth then occurs through static diffusion of gas out of the tissues. In such a scenario, the marine mammal would need to be in a gas-supersaturated state for enough time for bubbles to become a problematic size. Fahlman et al. (2014) evaluated dive data recorded from sperm, killer, long-finned pilot, Blainville's beaked and Cuvier's beaked whales before and during exposure to low (1 – 2 kHz) and mid (2 – 7 kHz)

frequency active sonar in an attempt to determine if either differences in dive behavior or physiological responses to sonar are plausible risk factors for bubble formation. Note that SURTASS LFA sonar is transmitted between 100 – 500 Hz, which is well below the low frequency sonar in these studies. The authors suggested that carbon dioxide may initiate bubble formation and growth, while elevated levels of dinitrogen may be important for continued bubble growth. The authors also suggest that if carbon dioxide plays an important role in bubble formation, a cetacean escaping a sound source may experience increased metabolic rate, carbon dioxide production, and alteration in cardiac output, which could increase risk of gas bubble emboli.

Despite the increase in research and literature, there remains scientific disagreement and a lack of scientific data regarding the evidence for gas bubble formation as a causal mechanism between certain types of acoustic exposures and stranding events in marine mammals. These issues include: (1) received acoustic exposure conditions; (2) pathological interpretation; (3) acoustic exposure conditions required to directly induce physiological trauma; (4) behavioral reactions caused by sound exposure such as atypical dive patterns; and (5) the extent of post-mortem artifacts (Southall et al. 2007b).

The hypotheses for gas bubble formation related to beaked whale strandings is that beaked whales potentially have strong avoidance responses to mid-frequency active (MFA) sonars because they sound similar to their main predator, the killer whale (Cox et al. 2006; Southall et al. 2007b; Zimmer and Tyack 2007; Baird et al. 2008; Hooker et al. 2009b). Because SURTASS LFA sonar transmissions are lower in frequency (less than 500 Hz) and dissimilar in characteristics from those of marine mammal predators, the above scientific studies do not provide evidence that SURTASS LFA sonar has caused behavioral reactions, specifically avoidance responses, in beaked whales. Thus, SURTASS LFA sonar transmissions are not expected to cause gas bubble formation or marine mammal strandings.

8.2.1.1 *Nitrogen Decompression*

Although not a direct injury, variations in marine mammal diving behavior or avoidance responses could result in nitrogen tissue supersaturation and nitrogen off-gassing. Nitrogen supersaturation and off-gassing levels could result in deleterious vascular and tissue bubble formation (Jepson et al. 2003; Saunders et al. 2008a; Hooker et al. 2012). Nitrogen off-gassing occurring in human divers is called decompressions sickness. The mechanism for bubble formation from saturated tissues would be indirect and also different from rectified diffusion, but the effects would be similar. The potential process for this to occur is hypothetical and under debate in the scientific community (Saunders et al. 2008b; Hooker et al. 2012). It is speculated if exposure to a startling sound elicits a rapid ascent to the surface, tissue gas saturation sufficient for the evolution of nitrogen bubbles might result (Jepson et al. 2003; Fernandez et al. 2005a; Hooker et al. 2012). In this scenario, the rate of ascent would need to be sufficiently rapid to compromise behavioral or physiological protections against nitrogen bubble formation. Fahlman

et al. (2009) suggested that repeated dives might result in tissue and blood levels of nitrogen sufficient to cause symptomatic bubble formation.

Previous modeling suggests even unrealistically rapid rates of ascent from normal dive behaviors are unlikely to result in supersaturation to the extent bubble formation would be expected in beaked whales (Zimmer and Tyack 2007). Tyack et al. (2006) suggested emboli observed in animals exposed to MFA sonar (Jepson et al. 2003; Fernandez et al. 2005a) could stem from a behavioral response that involves repeated dives, shallower than the depth at which lung collapse would occur. A bottlenose dolphin was trained to repetitively dive to elevate nitrogen saturation to the point that asymptomatic nitrogen bubble formation was predicted to occur. However, inspection of the vascular system of the dolphin via ultrasound did not demonstrate the formation of any nitrogen gas bubbles (Houser 2010).

More recently, modeling has suggested that the long, deep dives performed regularly by beaked whales over a lifetime could result in the saturation of tissues (e.g., fat, bone lipid) to the point that they are supersaturated when the animals are at the surface (Saunders et al. 2008b; Hooker et al. 2009a). Proposed adaptations for prevention of bubble formation under conditions of persistent issue saturation have been suggested (Fahlman et al. 2006; Hooker et al. 2009a). Since bubble formation is facilitated by compromised blood flow, it has been suggested that rapid stranding may lead to bubble formation in animals with supersaturated tissues because of the stress of stranding and the cardiovascular collapse that can accompany it (Houser 2010).

A fat embolic syndrome was identified by Fernandez et al. (2005b) coincident with the identification of bubble emboli in stranded beaked whales. The fat embolic syndrome was the first pathology of this type identified in marine mammals, and was thought to possible arise from the formation of bubbles in fat bodies, which subsequently resulted in the release of fat emboli into the blood stream. Recently, Dennison et al. (2011) reported on investigations of dolphins stranded in 2009 and 2010. Using ultrasound, the authors identified gas bubbles in kidneys from 21 of 22 live-stranded dolphins and in the liver from two of 22. The authors postulated stranded animals are unable to recompress by diving, and thus may retain bubbles that are otherwise re-absorbed in animals that can continue to dive. The researchers concluded minor bubble formation can be tolerated since the majority of stranded dolphins released did not re-strand (Dennison et al. 2011). Recent modeling by Kvadsheim (2012) determined behavioral and physiological responses to sonar have the potential to result in bubble formation. However, the observed behavioral responses of cetaceans to sonar do not imply any significantly increased risk over what may otherwise occur normally in individual marine mammals. As a result, no marine mammals addressed in this analysis are given differential treatment due to the possibility for acoustically mediated bubble growth.

8.2.2 Hearing Loss – Permanent Threshold Shift and Temporary Threshold Shift

The most familiar effect of exposure of high intensity sound is hearing loss, meaning an increase in the hearing threshold. The meaning of the term “hearing loss” does not equate to “deafness.” This phenomenon is called a noise-induced threshold shift, or simply a threshold shift. If high-

intensity sound over stimulates tissues in the ear, causing a threshold shift, the impacted area of the ear (associated with and limited by the sound's frequency band) no longer provides the same auditory impulses to the brain as before the exposure (Ketten 2012). The distinction between PTS and TTS is based on whether there is a complete recovery of a threshold shift following a sound exposure. If the threshold shift eventually returns to a zero (i.e., the threshold returns to the pre-exposure value), the threshold shift is a TTS. TTS may last from minutes to days. The following physiological mechanisms may result in TTS:

1. Reduced sensitivity of the sensory hair cells in the inner ear as a result of their being over-stimulated;
2. Modification of the chemical environment within sensory cells;
3. Displacement of certain inner ear membranes;
4. Increased blood flow; and
5. Post-stimulation reduction in both efferent (impulses traveling from the central nervous system to the peripheral sensory tissue) and sensory output (Kryter 1994; Southall et al. 2007b).

For TTS, full recovery of the hearing loss (to the pre-exposure threshold) has been determined from studies of marine mammals, and this recovery occurs within minutes to hours for the small amount of TTS that have been experimentally induced (Nachtigall et al. 2004; Finneran et al. 2005; Finneran and Schlundt 2010). The recovery time is related to the exposure duration, SEL, and the magnitude of the threshold shift, with larger threshold shifts and longer exposure durations requiring longer recovery times (Finneran et al. 2005; Mooney et al. 2009a; Mooney et al. 2009b; Finneran and Schlundt 2010). In some cases, threshold shifts as large as 50 dB (loss in sensitivity) have been temporary, although recovery sometimes required as much as 30 days (Ketten 2012). If the threshold shift does not return to zero but leaves some finite amount of threshold shift, then that remaining threshold shift is a PTS. Figure 36 shows one hypothetical threshold shift that completely recovers, a TTS, and one that does not completely recover, leaving some PTS. The actual amount of threshold shift depends on the amplitude, duration, frequency, temporal pattern of the sound exposure, and on the susceptibility of the individual animal.

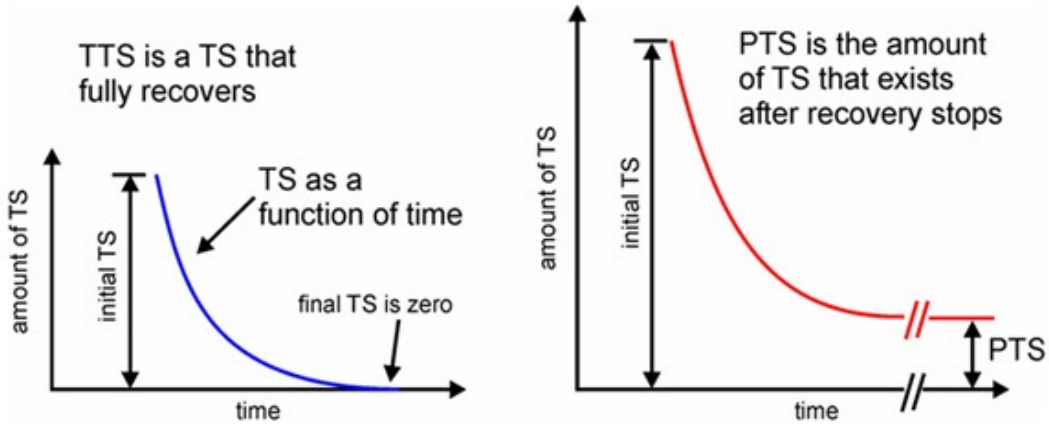

Figure 36. Two Hypothetical Threshold Shifts, Temporary and Permanent.

Both auditory trauma and auditory fatigue may result in hearing loss. Many are familiar with hearing protection devices (i.e., ear plugs) required in many occupation settings where persistent noise could otherwise cause auditory fatigue and possibly result in hearing loss. The mechanisms responsible for auditory fatigue differ from auditory trauma and would primarily consist of metabolic fatigue and exhaustion of the hair cells and cochlear tissues. Note that the term "auditory fatigue" is often used to mean "temporary threshold shift;" however, we use a more general meaning to differentiate fatigue mechanism (e.g., metabolic exhaustion and distortion of tissues) from trauma mechanisms (e.g., physical destruction of cochlear tissues occurring at the time of exposure).

Hearing loss in marine mammals has been studied by a number of investigators (Finneran et al. 2000b; Schlundt et al. 2000a; Finneran et al. 2002b; Nachtigall et al. 2003; Finneran et al. 2005; Finneran et al. 2007; Lucke et al. 2009; Mooney et al. 2009a; Mooney et al. 2009b; Finneran and Schlundt 2010). The studies of marine mammal auditory fatigue were all designed to determine relationships between TTS and exposure parameters such as level, duration, and frequency.

In these studies, hearing thresholds were measured in trained marine mammals before and after exposure to intense sounds. The difference between the pre-exposure and post-exposure thresholds indicated the amount of TTS. Species studied include the bottlenose dolphin (*Tursiops truncatus*) (total of nine individuals), beluga whale (two), harbor porpoise (one), finless porpoise (*Neophocaena phocaenoides*) (two), California sea lion (*Zalophus californianus*) (three), harbor seal (one), and Northern elephant seal (one). Some of the more important data obtained from these studies are onset-TTS levels – exposure levels sufficient to cause a just-measurable amount of TTS, often defined as six dB of TTS (Schlundt et al. 2000a). These criteria for onset-TTS are very conservative, and it is not clear that this level of threshold shift would have a functional effect on the hearing of a marine mammal in the ocean.

Some of the primary findings of the marine mammal TTS studies are:

- The growth and recovery of TTS are analogous to those in terrestrial mammals. This means that, as in terrestrial mammals, threshold shifts primarily depend on the amplitude, duration, frequency, content, and temporal pattern of the sound exposure.
- The amount of TTS increases with exposure sound pressure level and the exposure duration.
- For continuous sounds, exposures of equal energy lead to approximately equal effects (Ward 1997). For intermittent sounds, less hearing loss occurs than from a continuous exposure with the same energy (some recovery will occur during the quiet period between exposures) (Kryter et al. 1965; Ward 1997).
- SEL is correlated with the amount of TTS and is a good predictor for onset-TTS from single, continuous exposures with similar durations. This agrees with human TTS data presented by Ward et al. (Ward et al. 1958; Ward et al. 1959b; Ward et al. 1959a). However, for longer duration sounds – beyond 16 to 32 seconds, the relationship between TTS and SEL breaks down and duration becomes a more important contributor to TTS (Finneran and Schlundt 2010). Still, for a wide range of exposure durations, SEL correlates reasonably well to TTS growth (Popov et al. 2014).
- The maximum TTS after tonal exposures occurs one-half to one octave above the exposure frequency (Schlundt et al. 2000a; Finneran et al. 2007). TTS from tonal exposures can thus extend over a large (greater than one octave) frequency range.
- Nachtigall and Supin (2013) demonstrated that a false killer whale decreased its hearing sensitivity when signaled that a loud sound was about to arrive.
- The amount of observed TTS tends to decrease with increasing time following the exposure; however, the relationship is not monotonic. The amount of time required for complete recovery of hearing depends on the magnitude of the initial shift; for relatively small shifts recovery may be complete in a few minutes, while large shifts (e.g., 40 dB) require several days for recovery.
- TTS can accumulate across multiple intermittent exposures, but the resulting TTS will be less than the TTS from a single, continuous exposure with the same SEL. This means that predictions based on total sSEL will overestimate the amount of TTS from intermittent exposures.

Although TTS data on ESA-listed odontocetes considered in this opinion (i.e., Main Hawaiian Island false killer and sperm whale) are rare, studies of TTS on harbor porpoises using seismic airguns as a stimulus has been conducted (Lucke et al. 2009; Kastelein et al. 2017). Unlike SURTASS LFA sonar, airguns produce an impulsive signal and have a broad frequency range. Nevertheless, airguns have substantial energy in the low frequency region. To quantify TTS caused by airgun exposure and the subsequent hearing recovery Kastelein et al. (2017) tested the hearing of a harbor porpoise by means of a psychophysical technique. TTS was observed after exposure to 10 and 20 consecutive shots fired from two airguns simultaneously (SELcum: 188 and 191 dB re 1 μPa^2s) with mean shot intervals of around 17 sesconds. Although most of the airgun sounds' energy was below 1 kHz, statistically significant initial TTS1-4 (1-4 min after

sound exposure stopped) of ~4.4 dB occurred only at the hearing frequency 4 kHz, and not at lower hearing frequencies tested (0.5, 1, and 2 kHz). Recovery occurred within 12 minutes post-exposure.

In a study on the effects of noise level and duration of TTS in a bottlenose dolphin, Mooney et al. (2009a) exposed a bottlenose dolphin to octave-band noise (four to eight kHz) of varying durations (two to 30 minutes) and sound pressure level received levels (130 to 178 dB re: 1 µPa). The results of the Mooney et al. study indicated that shorter-duration sound exposures often require greater sound energy to induce TTS than longer-duration exposures and also supported the trend that longer duration exposures often induce greater amounts of TTS, which concurrently require longer recovery times.

In a controlled exposure experiment, Mooney et al. (2009b) demonstrated that MFA sonar could induce temporary hearing loss in a bottlenose dolphin. Temporary hearing loss was induced by repeated exposure to a SEL of 214 dB re: 1 μPa^2-sec. Subtle behavioral alterations were also associated with the sonar exposures. At least with one odontocete species (common bottlenose dolphin) sonar can induce both TTS and mild behavioral effects; but exposures must be prolonged with high exposure levels to generate these effects. The received level used in the Mooney et al. (2009b) experiment was a sound pressure level of 203 dB, which equates to the received level approximately 40 m (131 ft) from an MFA sonar operated at a sound pressure level of 235 dB (SL). Mooney et al. (2009b) concluded that in order to receive a SEL of near 214 dB, an animal would have to remain in proximity of the moving sonar, which is transmitting for 0.5 seconds every 24 seconds, over an approximately two to 2.5 minute period, an unlikely situation.

SELs necessary for TTS onset for pinnipeds in water have been measured for harbor seals, California sea lions, and Northern elephant seals. As reported by Southall et al. (2007b), Kastak et al. (2005) presented comparative analysis of underwater TTS for pinnipeds. This indicated that in harbor seals, a TTS of approximately six dB occurred with a 25-minute exposure to 2.5 kHz octave-band noise of 152 dB sound pressure level (183 dB SEL); a California sea lion showed TTS-onset under the same conditions at 174 dB sound pressure level (206 dB SEL); and a Northern elephant seal under the same conditions experienced TTS-onset at 172 dB sound pressure level (204 dB SEL). Finneran et al. (2003) exposed two California sea lions to single underwater pulses from an arc-gap transducer and found no measurable TTS following exposures of up to 183 dB sound pressure level (215 dB SEL).

Animals suffering from TTS over longer periods of time, such as days, may be considered to have a change in a biologically significant behavior, as they may be prevented from detecting sounds that are biologically relevant, including communication sounds, sounds of prey, or sounds of predators. As noted by Mooney et al. (2009a), shorter duration sound exposures can require greater sound energy to induce TTS than longer duration exposures, and longer duration exposures can induce greater amounts of TTS. In assessing the potential for LFA sonar

transmissions to cause TTS, the much shorter length of the LFA sonar signal (typically one minute) versus the above studies (two to 30 minutes) must be considered.

Tougaard et al. (2014) report that although TTS by definition is considered a temporary effect, recent experiments with terrestrial mammals suggest that an animal's auditory system may not recover fully from severe TTS and that permanent denigration of the cochlear nerve system may result from recoverable TTS episodes and possibly repeated severe TTS can cause accumulated damage that could lead to a neurologically-based PTS. Additionally, the authors reported on the potential for earlier TTS studies to have overestimated the levels for onset of TTS due to high levels of ambient noise in the experimental setting as well as the use of older animals without optimal hearing (Tougaard et al. 2014). While other recent research has shown that harbor and finless porpoises are more sensitive to sound than expected from extrapolations of research results on bottlenose dolphins (Schlundt et al. 2000a), Tougaard et al. (2014) caution that it is not known whether these results were due to differences in experimental methodology, masking levels, or the age and health of the subject animals, but the reliability of extrapolating TTS thresholds between species relies on careful examination of such factors.

Hearing loss resulting from auditory fatigue could effectively reduce the distance over which animals can communicate, detect biologically relevant sounds such as predators, and echolocate (for odontocetes). The costs to marine mammals with TTS, or even some degree of PTS have not been studied; however, hearing loss could have consequences to biologically important activities (e.g., intraspecific communication, foraging, and predator detection) that affect survivability and reproduction. The brief amount of time marine mammals are expected to experience TTS is unlikely to significantly impair their ability to communicate, forage, or breed and not expected to lead to long-term fitness level consequences at the individual or population level. However, this is dependent on the amount of time the instance of TTS lasts as it has the potential to last from only seconds to minutes or hours to days (NMFS 2018a). Although PTS is a permanent shift in hearing, it is not the same as deafness and to our knowledge there are no published studies on the long-term effects of PTS on marine mammal fitness. Conceivably, PTS could result in changes to individuals' ability to communicate, breed, avoid predators and forage, but it is unclear if these impacts would significantly impact their fitness. For example, results from two years (2009 and 2010) of intensive monitoring by independent scientists and Navy observers in the Southern California and Hawaii Range Complexes have recorded an estimated 161,894 marine mammals with no evidence of distress or unusual behavior observed during Navy activities.

8.2.3 Behavioral Responses

One potential deleterious effect from SURTASS LFA sonar is change in a biologically significant behavior. The National Research Council (NRC 2005b) discussed biologically significant behaviors and possible effects and states that an action or activity becomes biologically significant to an individual animal when it affects the ability of the animal to grow, survive, and reproduce. These are the effects on individuals that can have population-level consequences and affect the viability of the species (NRC 2005b).

The behavioral response of a marine mammal to an anthropogenic sound will depend on the frequency, duration, temporal pattern and amplitude of the sound as well as the animal's condition, prior experience with the sound and the context in which the sound is encountered (i.e., what the animal is doing at the time of the exposure, the distance from the sound source, and whether it is perceived as approaching or moving away) (Wartzok et al. 2003). For marine mammals, a review of responses to anthropogenic sound was first conducted by Richardson and others (Richardson et al. 1995g). Other reviews (Nowacek et al. 2007; Southall et al. 2007b; Southall et al. 2009; Ellison et al. 2012a) address studies conducted since 1995 and focus on observations where the received sound level of the exposed marine mammal(s) was known or could be estimated. Most recently, Southall et al. (2016b) and Southall et al. (2019b) reviewed field experiments studying cetacean responses to simulated or actual military mid frequency sonar bands (i.e. 1 to 8 kHz; higher frequencies than the LFA sonar considered in this opinion). It should be noted that these experiments were deliberately designed to demonstrate the onset of response and not to produce adverse effects. Overall, the results from the Southall et al. (2016b) and Southall et al. (2019b) review determined that some individuals of different species display clear yet varied responses, some of which have negative implications, while others appear to tolerate relatively high levels, although such exposures may have other consequences not measured. The studies reviewed in Southall et al. (2016b) and Southall et al. (2019b) are discussed further in Section 8.2.3.2.

Except for some vocalization changes that may be compensating for concurrent auditory masking, all behavioral reactions are assumed to occur due to a preceding stress or cueing response, however stress responses cannot be predicted directly due to a lack of scientific data. Responses can also overlap. For example, an increased respiration rate is likely to be coupled with a flight response. Differential responses are expected among and within species since hearing ranges vary across species, the behavioral ecology of individual species is unlikely to completely overlap, and individuals of the same species may react differently to the same or similar, stressor.

Southall et al. (2007b) synthesized data from many past behavioral studies and observations to determine the likelihood of behavioral reactions to specific sound level exposures. While in general, the louder the sound source the more intense the behavioral response, it was clear that the proximity of a sound source and the animal's experience, motivation, and conditioning were also critical factors influencing the response (Southall et al. 2007b). After examining all of the available data, the authors felt that the derivation of thresholds for behavioral response based solely on exposure level was not supported because context of the animal at the time of sound exposure was an important factor in estimating response. Nonetheless, in some conditions consistent avoidance reactions were noted at higher sound levels dependent on the marine mammal species or group allowing conclusions to be drawn.

Additional discussion on potential behavioral reactions of ESA-listed marine species to Navy mid-frequency active sonar is available in the most recent NMFS opinions for Navy training and

testing in the Atlantic Fleet Training and Testing, Gulf of Alaska Training and Testing, Hawaii-Southern California Training and Testing, and the Mariana Islands Training and Testing study areas (NMFS 2015c; NMFS 2017; NMFS 2018c; NMFS 2018b). However, due to differences between mid- and low-frequency active sonar, we primarily rely on the literature, described below, that primarily addresses potential behavioral responses of marine mammals to low-frequency sound sources (predominantly from sonar).

8.2.3.1 *Low Frequency Sound Scientific Research Program*

As discussed previously in section 2.1.1.1, the LFS SRP in 1997 through 1998 provided important results on, and insights into, the types of responses of baleen whales to LFA sonar signals and how those responses scaled relative to received level and context. The results of the LFS SRP confirmed that some portion of the total number of whales exposed to LFA sonar responded behaviorally by changing their vocal activity, moving away from the source vessel, or both, but the responses were short-lived (Clark and Fristrup 2001b).

In the LFS SRP LFA sonar playback experiment (Phase II), migrating gray whales avoided exposure to LFA sonar signals (SLs of 170 and 178 dB re: 1 µPa [rms] sound pressure level) when the source was placed in the center of their migration corridor. Responses were similar for the 170 dB SL LFA sonar stimuli and for the 170 dB SL 1/3rd-octave, band-limited noise with timing and frequency band similar to the LFA sonar stimulus. However, during the LFA sonar playback experiments, in all cases, whales resumed their normal activities within tens of minutes after the initial exposure to the LFA sonar signal (Clark and Fristrup 2001b). Essentially, the whales made minor course changes to go around the source. When the source was relocated within the outer portion of the migration corridor (twice the distance offshore), and the SL was increased to reproduce the same sound field for the central corridor playback condition, the gray whales showed little to no response to the LFA sonar source. This result stresses the importance of context in interpreting the animals' behavioral responses to underwater sounds and demonstrates that received level is not necessarily a good predictor of behavioral impact.

The Phase II research also demonstrated that it may not be valid to generalize results from inshore studies (2 km [1.1 nmi] from shore when 50 percent of the whales avoided SURTASS LFA sonar stimuli at received levels of 141+3 dB) to sources that are offshore (4 km [2.2 nmi] from shore) of migrating whales (whales did not avoid offshore sources at received levels of 140 dB). This implies that the inshore avoidance model, in which 50 percent of the whales avoid exposure to levels of 141+3 dB, may not be valid for whales in proximity to an offshore source (Buck and Tyack 2000).

The LFS SRP also conducted field tests to examine the effects of LFA sonar transmissions on foraging fin and blue whales off San Nicolas Island, California (Phase I). Overall, whale encounter rates and dive behavior appeared to be more strongly linked to changes in prey abundance associated with oceanographic parameters rather than LFA sonar sound transmissions (Croll et al. 2001b). However, in a separate study on the Atlantic coast, five out of six North Atlantic right whales exposed to an acoustic alarm interrupted their foraging dives, although the

alarm signal was long in duration, lasting several minutes, and purposely designed to elicit a reaction from the animals as a prospective means to protect them from ship strikes (Nowacek et al. 2004b). Although the animal's received sound pressure level was similar in the latter two studies (133 to 150 dB re: 1 µPa), the frequency, duration, and temporal pattern of signal presentation were different. Additionally, the North Atlantic right whales did not respond to playbacks of either North Atlantic right whale social sounds or vessel noise, highlighting the importance of the sound characteristics, species differences, and individual sensitivity in producing a behavioral reaction.

In the final phase of the LFS SRP (Phase III), the effect of LFA sonar on humpback whales during the winter mating season was investigated. Both Miller et al. (2000b) and Fristrup et al. (2003) published results from tests conducted with male humpback singers off the Big Island, Hawaii during which they evaluated variation in song length as a function of exposure to LFA sonar sounds. Fristrup et al. (2003) used a larger data set to describe song length variability and to explain song length variation in relation to LFA sonar broadcasts. In spite of methodological and sample size differences, the results of the two analyses were generally in agreement, and both studies indicated that humpback whales might lengthen their songs in response to low frequency broadcasts. The Fristrup et al. (2003) results also provided a detailed picture of short-term response as compared to behavioral variation observed in the absence of the stimuli. These responses were relatively brief in duration, with all observed effects occurring within two hours of the last LFA sonar source transmission. It should be noted that these effects were not obvious to the acoustic observers on the scene, but were revealed by careful, complex post-test statistical analyses (Fristrup et al. 2003). Aside from the delayed responses, other measures failed to indicate cumulative effects from LFA sonar broadcasts, with song-length response being dependent solely on the most recent LFA sonar transmission, and not the immediate transmission history. The modeled seasonal factors (changes in density of whales sighted near shore) and diurnal factors (changes in surface social activities) did not show trends that could be plausibly explained by cumulative exposure. Increases in song length from early morning to afternoon were the same on days with and without LFA sonar transmissions, and the fraction of variation in song length that could be attributed to LFA sonar broadcast was small (less than ten percent). Fristrup et al. (2003) found high levels of natural variability in humpback song length and interpreted the whales' responses to LFA sonar broadcasts to indicate that exposure to LFA sonar would not impose a risk of dramatic changes in humpback whale singing behavior that would have demographic consequences.

Taken together, the data generated during the three phases of the LFS SRP did not support the initial hypothesis that most baleen whales exposed to received levels near 140 dB would exhibit behavioral changes and avoid the area. These experiments, which exposed baleen whales to received level ranging from 120 to about 155 dB, detected only minor, short-term behavioral responses. As documented below, the conclusions from the LFS SRP are supported by other studies of whale responses to low frequency, anthropogenic sounds.

8.2.3.2 *Other Literature*

Richardson et al. (1995g) noted that avoidance reactions are the most obvious manifestations of disturbance in marine mammals. Richardson et al. (1985b) and Richardson (1997) used controlled playback experiments to study the response of bowhead whales in Alaska. In their studies, bowhead whales tended to avoid drill ship noise at estimated received levels of 110 to 115 dB re: 1 µPa (rms) and seismic sources at estimated received levels of 110 to 132 dB re: 1 µPa. Richardson et al. (1995g) concluded that some marine mammals would tolerate continuous sound at received levels above 120 dB re: 1 µPa (rms) for a few hours. These authors concluded that most marine mammals would avoid exposures to received levels of continuous underwater noise greater than 140 dB re: 1 µPa (rms) when source frequencies were in the animal's most sensitive hearing range.

Several authors noted that migrating whales are likely to avoid stationary sound sources by deflecting their course slightly as they approached a source (LGL and Greenridge 1987 in Richardson et al. 1995g). A study examined responses of gray whales migrating along the California coast to various sound sources located in their migration corridor (Malme et al. 1983; Malme et al. 1984). Gray whales showed statistically significant responses to four different underwater playbacks of continuous sounds at received levels of approximately 120 dB re: 1 µPa (rms). The sources of the playbacks were typical of a drillship, semisubmersible, drilling platform, and production platform.

Bowhead and gray whales showed clear patterns of short-term, behavioral disturbance in response to a variety of actual and simulated vessel activity and noise (Malme et al. 1983; Richardson et al. 1985a). Richardson et al. (1995c) noted that whales have been seen within a few kilometers of operating seismic vessels, although they added that any discomfort the seismic sound pulses may have caused remains unknown. Humpback whales showed similar patterns on their summering grounds (Bauer and Herman 1986) and on their wintering grounds (Bauer 1986) in response to vessel noise. Richardson et al. (1995c) argued that intermittent pulses with peak levels between 160 re: 1 µPa (rms) to 180 dB re: 1 µPa (rms) are less likely to cause discomfort than continuous sounds at the same sound pressure levels.

In the Caribbean Sea, sperm whales avoided exposure to mid-frequency submarine sonar pulses, in the range 1 to 10 kHz (IWC 2005). Blue and fin whales have occasionally been reported in areas ensonified by airgun pulses. Systematic data on their reactions to airguns are generally lacking. Sighting by observers on seismic vessels off the United Kingdom suggest that, at times of good sightability, the number of blue, fin, sei, and humpback whales seen when airguns are shooting are similar to the numbers seen when the airguns are not shooting (Stone 1997; Stone 1998; Stone 2000; Stone 2001). However, fin and sei whale sighting rates were higher when airguns were shooting, which may be due to a tendency to remain at or near the surface at times of airgun operation (Stone 2003). The analysis of the combined data from all years indicated that baleen whales stayed farther from airguns during periods of shooting (Stone 2003). Baleen whales also altered course more often during periods of shooting and more were headed away

from the vessel at these times, indicating some level of localized avoidance of seismic activity (Stone 2003).

Sperm whales reacted to military sonar, apparently from a submarine, by dispersing from social aggregations, moving away from the sound source, remaining relatively silent, and becoming difficult to approach (Watkins et al. 1985c). The submarine sonar signals were of several kinds with frequencies from 3.25 kHz to 8.4 kHz in pulses of 0.145 to 0.45 seconds, usually in short sequences of 4 to 20 or more signals at rates of approximately one to five per minute. These signals were heard every few hours on some days, and they were audible during some portion of 11 of the 13 days that we were with whales (Watkins et al. 1985c). Captive bottlenose dolphins and a beluga whale exhibited changes in behavior when exposed to one second pulsed sounds at frequencies similar to those emitted by multi-beam sonar that is used by geophysical surveys (Ridgway et al. 1997; Schlundt et al. 2000b), and to shorter broadband pulsed signals (Finneran et al. 2000a; Finneran et al. 2002a).

Behavioral changes often appear to be deliberate attempts to avoid a sound exposure or to avoid the location of the exposure site during subsequent tests (Finneran et al. 2000a; Schlundt et al. 2000b). Dolphins exposed to one-second intense tones exhibited short-term changes in behavior above received sound levels of 178 to 193 dB re: 1 µPa (rms) and beluga whales did so at received levels of 180 to 196 dB and above. Received levels necessary to elicit such reactions to shorter pulses were higher (Finneran et al. 2000a; Finneran et al. 2002a). Test animals sometimes vocalized after exposure to pulsed, mid-frequency sound from a watergun (Finneran et al. 2002b). In some instances, animals exhibited aggressive behavior toward the test apparatus (Ridgway et al. 1997; Finneran et al. 2000a).

Nowacek et al. (2004a) conducted controlled exposure experiments on North Atlantic right whales using ship noise, social sounds of conspecifics, and an alerting stimulus (frequency modulated tonal signals between 500 Hz and 4.5 kHz). Animals were tagged with acoustic sensors (D-tags) that simultaneously measured movement in three dimensions. Data from the experiment were collected only for approaches where the vessel passed within one nautical mile of the whale. Whales reacted strongly to alert signals at received levels of 133 to 148 dB re: 1 µPa (rms) sound pressure level, mildly to conspecific signals, and not at all to ship sounds or actual vessels. This was a 20 min continuous signal. The alert stimulus caused whales to immediately cease foraging behavior and swim rapidly to the surface.

There is also evidence that wild animals respond to human disturbance in the same way that they respond to predators (Gill and Sutherland 2001; Frid and Dill 2002; Frid 2003; Beale and Monaghan 2004; Romero 2004). These responses manifest themselves as stress responses (in which an animal perceives human activity as a potential threat and undergoes physiological changes to prepare for a flight or fight response or more serious physiological changes with chronic exposure to stressors), interruptions of essential behavioral or physiological events, alteration of an animal's time budget, or some combinations of these responses (Sapolsky et al. 2000; Frid and Dill 2002; Romero 2004; Walker et al. 2005). These responses have been

associated with abandonment of sites (Sutherland and Crockford 1993), reduced reproductive success (Giese 1996; Müllner et al. 2004), and the death of individual animals (Daan et al. 1996).

Brownell (2004) reported observations of the effects of behavioral disturbance on the endangered Western North Pacific population of gray whales off the northeast coast of Sakhalin Island associated with seismic activities in that region. In 1997, various behavioral disturbances concomitant with seismic activities were observed including changes in swimming speed and orientation, respiration rates, and distribution offshore. Cumulative impacts of these short-term disturbances are not known. In 2001, seismic activities were conducted in the known feeding area of these whales. It was observed that whales left the feeding ground during these activities and moved to areas farther south. They only returned to the feeding ground after the seismic activities ceased days later. The potential impacts on these whales, especially mother-calf pairs and "skinny whales," of being displaced to the south outside the normal feeding area are not known but are cause for concern.

One study of blue whales reported that when pulses from airguns were produced off Oregon, blue whales continued vocalizing at the same rate as before the pulses, suggesting that at least their vocalization behavior was undisturbed by the sound (McDonald et al. 1993).

Watkins (1986a) reviewed data on the reactions of fin, humpback, North Atlantic right, and minke whales that were exposed to continuous, broadband low-frequency shipping and industrial noise in Cape Cod Bay. Watkins (1986a) concluded that underwater sound was the primary cause of a reaction in these species of whales and that whales responded to acoustic stimuli in their range of hearing. Watkins also noted that whales showed the strongest reactions to sounds in the 15 Hz to 28 kHz range, although negative reactions (avoidance, interruptions in vocalizations, etc.) were generally associated with sounds that were either unexpected, too loud, suddenly louder or different, or perceived as being associated with a potential threat (such as an approaching ship on a collision course). In particular, whales seemed to react negatively when they were within 100 m (328 ft) of the source or when received levels increased suddenly in excess of 12 dB relative to ambient sounds. At other times, the whales ignored the source of the signal and all four species habituated to these sounds. Nevertheless, Watkins concluded that whales ignored most sounds in the background of ambient noise, including the sounds from distant human activities even though these sounds may have had considerable energies at frequencies well within the whale's range of hearing. Further, Watkins (1986a) noted that fin whales were initially the most sensitive of the four species of whales, followed by humpback whales; North Atlantic right whales were the least likely to be disturbed and generally did not react to low-amplitude engine noise. By the end of this period of study, Watkins (1986a) concluded that fin and humpback whales have generally habituated to the continuous, broad-band, noise of Cape Cod Bay while North Atlantic right whales did not appear to change their response. This study covered a long enough period (the data covered 25 years of time) to provide some insight into possible long-term effects of low-frequency noise on whales, particularly since the four whale species would be exposed to continuous, low-frequency noise from shipping and

other industrial sources. Given that whales in Cape Cod Bay reacted negatively to these continuous sources of anthropogenic sounds only under specific circumstances and, over time, habituated to these sounds (rather than abandoned the area), it seems unlikely that an additional, intermittent signal lasting from six to 100 seconds that is designed to mimic background, low frequency sound would have a greater negative effect on at least these species of whales (fin, humpback, North Atlantic right, and minke whales). The studies associated with the LFS SRP suggest the same conclusions may also apply to blue, gray, and fin whales.

A study of an LFA sonar system that was being developed for use by the British Navy monitored the behavioral responses of marine mammals to the LFA sonar (Aicken et al. 2005). During these trials, fin whales, sperm whales, Sowerby's beaked whales (*Mesoplodon bidens*), long-finned pilot whales (*Globicephala melas*), Atlantic white-sided dolphins (*Lagenorhynchus acutus*), and common bottlenose dolphins were observed and recorded vocalizing. These studies found no evidence of behavioral responses that could be attributed to the LFA sonar during these trials (some of the responses that were observed may have been to the vessels used for the monitoring).

Low-frequency signals of the Acoustic Thermometry of Ocean Climate sound source were not found to affect dive times of humpback whales in Hawaiian waters (Frankel and Clark 2000) or to overtly affect Northern elephant seal dives off California (Costa et al. 2003). However, they did produce subtle effects that varied in direction and degree among the individual seals, again illustrating the equivocal nature of behavioral effects and consequent difficulty in defining and predicting them.

Work by Risch et al. (2012) found that humpback whale vocalizations were reduced concurrently with pulses from the low frequency Ocean Acoustic Waveguide Remote Sensing (OAWRS) source located approximately 200 km (108 nmi) away. The OAWRS source appears to have affected more whales, by producing a greater response with a lower sound SL, than reported from the Phase III of the LFS SRP, even though OAWRS had a lower received level (88 to 110 dB re: 1 µPa) than the LFA signal. This strongly suggests that other acoustic characteristics may be responsible for the difference in observed behavioral responses. Risch et al. (2012) stated that due to differences in behavioral context, location, and proximity to the source, it is difficult to compare their findings directly to Phase III of the LFS SRP. These observations are consistent with the importance of considering context in predicting and observing the level and type of behavioral response to anthropogenic signals (Ellison et al. 2012a). Gong et al. (2014) reported on their reassessment of the effects from exposure to the OAWRS source on humpback whales and determined that the constant occurrence rate of humpback whale songs indicated that they low frequency OAWRS source transmissions had no effect on humpback whale song, contrary to what Risch et al. (2012) reported. Gong et al. (2014) attributed the variation in song occurrence Risch et al. (2012) described as due to natural causes other than sonar since the change in song occurrence began before the OAWRS began transmitting. Risch et al. (2014) responded to the Gong et al. (2014) assessment by stating that both their original and the Gong et al. (2014)

findings may be correct, highlighting the multifactorial and context-dependent nature of behavioral responses. Risch et al. (2014) pointed out that the principal point of their original paper had been the importance of behavioral context, ambient noise, and the novelty received sounds when assessing anthropogenic impacts on marine mammals.

Antunes et al. (2014) conducted experiments using simulated European low frequency (one to two kHz) and mid-frequency (six to seven kHz) naval sonar to determine if transmission frequency had an effect on the behavioral response threshold for long-finned pilot whales. The experiment used a new method to quantify the dose threshold at which free-ranging long-finned pilot whales began to avoid an approaching vessel transmitting sonar, consisting of a statistical analysis of the movements of the whales to indicate changes in behavior and a Bayesian dose-response model using the observed response thresholds (Antunes et al. 2014). Long-finned pilot whale movements during the duration of sonar transmissions changed to indicate an avoidance response, with a shorter response duration than reported for other marine mammal species, including Cuvier's (*Ziphius cavirostris*) and Blainville's beaked whales (*Mesoplodon densirostris*) and killer whales. The observed response thresholds occurred at 50 percent higher levels (approximately 170 dB re: 1 µPa or 173 dB SEL) than described for other cetacean species (Antunes et al. 2014).

Miller et al. (2014) conducted eight controlled exposure experiments on killer whale groups using the same simulated European low frequency (one to two kHz) and mid-frequency (six to seven kHz) naval sonar used in the Antunes et al. (2014) experiments. The SL and distance to the source were increased during each exposure to reveal response thresholds. Changes in movements (swim speed and direction) during exposure to the transmitted sonar signals were evaluated as avoidance responses and animals began to avoid the sonar at received levels sound pressure levels of 142±15 dB re: 1 µPa (Miller et al. 2014). High levels of between and within individual variability were identified, and the context of exposure was recognized as an important factor, particularly since the sound source changed course to continue moving towards the animals, even after they exhibited avoidance responses.

Southall et al. (2007b) reviewed the relatively extensive behavioral observations of low frequency cetaceans exposed to non-pulse sources. While there are clearly major areas of uncertainty, Southall et al. (2007b) concluded that the literature indicated that there were no (or very limited) responses to received levels of 90 dB to 120 dB re: 1 µPa (rms) with an increasing probability of avoidance and other behavioral effects in the 120 to 160 dB re: 1 µPa (rms) (received level) range. See Southall et al. (2016b) and (Southall et al. 2019a) for an even more recent review on various controlled exposure experiments to measure behavioral response (or lack thereof) of marine mammals to sonar signals.

While not specific to the low-frequency sonar of the proposed action, both Goldbogen et al. (2013b) and Melcon et al. (2012) indicated that behavioral responses to simulated or operational MFA sonar were temporary, with whales resuming normal behavior quickly after the cessation of sound exposure. Further, responses were discernible for whales in certain behavioral states

(i.e., deep feeding), but not in others (i.e., surface feeding). As stated in Goldbogen et al. (2013b), when summarizing the responses of blue whales to simulated MFA sonar, "we emphasize that elicitation of the response is complex, dependent on a suite of contextual (e.g., behavioral state) and sound exposure factors (e.g., maximum received level), and typically involves temporary avoidance responses that appear to abate quickly after sound exposure." Melcon et al. (2012) reported that blue whales exposed to mid-frequency sonar in the Southern California Bight were less likely to produce low frequency calls (D calls) usually associated with feeding behavior. However, they were unable to determine if suppression of D calls reflected a change in their feeding performance or abandonment of foraging behavior that could potentially have impacts on individual fitness and eventually, population health. However, for this to be true, we would have to assume that an individual whale could not compensate for this lost feeding opportunity by either immediately feeding at another location, by feeding shortly after cessation of acoustic exposure, or by feeding at a later time. There is no indication this is the case, particularly since unconsumed prey would likely still be available in the environment following the cessation of acoustic exposure. Preliminary results from the 2010 to 2011 field season of an ongoing behavioral response study in Southern California waters indicated that in some cases and at low received levels, tagged blue whales responded to mid-frequency sonar but that those responses were mild and there was a quick return to their baseline activity (Southall et al. 2011a). Blue whales responded to a mid-frequency sound source, with a SL between 160 and 210 dB re: 1 µPa at 1 m and a received sound level up to 160 dB re: 1 µPa, by exhibiting generalized avoidance responses and changes to dive behavior during controlled exposure experiments (Goldbogen et al. 2013b). However, reactions were not consistent across individuals based on received sound levels alone, and likely were the result of a complex interaction between sound exposure factors such as proximity to sound source and sound type (mid-frequency sonar simulation vs. pseudo-random noise), environmental conditions, and behavioral state. Surface feeding whales did not show a change in behavior during controlled exposure experiments, but deep feeding and non-feeding whales showed temporary reactions that quickly abated after sound exposure. Whales were sometimes less than a mile from the sound source during controlled exposure experiments.

Differential vocal responding in marine mammals has been documented in the presence of seismic survey noise. An overall decrease in vocalization during active surveying has been noted in large marine mammal groups (Potter et al. 2007), while blue whale feeding/social calls increased when seismic exploration was underway (Di Lorio and Clark 2010), indicative of a potentially compensatory response to the increased noise level. Melcon et al. (2012) recently documented that blue whales decreased the proportion of time spent producing certain types of calls when simulated mid-frequency sonar was present. Castellote et al. (2012a) found that vocalizing fin whales in the Mediterranean Sea left the area where a seismic survey was being conducted and that their displacement persisted beyond the completion of the survey. At present, it is not known if these changes in vocal behavior corresponded to changes in foraging or any other behaviors. Controlled exposure experiments in 2007 and 2008 in the Bahamas recorded

responses of false killer whales, short-finned pilot whales, and melon-headed whales (*Peponocephala electra*) to simulated MFA sonar (Deruiter et al. 2013). The responses of exposures between species were variable. After hearing each MFA signal, false killer whales were found to "increase their whistle production rate and made more-MFA-like whistles" (Deruiter et al. 2013). In contrast, melon-headed whales had "minor transient silencing" after each MFA signal, while pilot whales had no apparent response. Consistent with the findings of other previous research (see, for example, (Southall et al. 2007b)), Deruiter et al. (2013) found the responses were variable by species and with the context of the sound exposure.

Most recently, Southall et al. (2019b) measured the degree of behavioral responses in blue whales (*Balaenoptera musculus*) to controlled noise exposure off the southern California coast. High-resolution movement and passive acoustic data were obtained from non-invasive archival tags whereas surface positions were obtained with visual focal follows. These controlled exposure experiments were used to obtain direct behavioral measurements before, during and after simulated and operational military mid-frequency active sonar, pseudorandom noise, and controls (no noise exposure). In all, more than 50% of blue whales in deep-feeding states responded during the controlled exposure experiments, whereas no changes in behavior were identified in shallow-feeding blue whales. Overall, the responses were generally brief, of low to moderate severity, and highly dependent on exposure context such as behavioral state, source-to-whale horizontal range and prey availability. As a result, the response probability did not follow a simple exposure–response model based on received exposure level.

8.2.4 Physiological Stress

Classic stress responses begin when an animal's central nervous system perceives a potential threat to its homeostasis. That perception triggers stress responses regardless of whether a stimulus actually threatens the animal; the mere perception of a threat is sufficient to trigger a stress response (Seyle 1950; Moberg 2000; Sapolsky 2006). Once an animal's central nervous system perceives a threat, it mounts a biological response or defense that may consist of a combination of several biological defense responses including, but not limited to, behavioral responses, autonomic nervous system responses, or neuroendocrine responses.

In the case of many stressors, the first and most economical (in terms of biotic costs) response is behavioral avoidance of the potential stressor or avoidance of continued exposure to a stressor. An animal's second line of defense to stressors involves the autonomic nervous system and the classical "fight or flight" response which includes the cardiovascular system, the gastrointestinal system, the exocrine glands, and the adrenal medulla to produce changes in heart rate, blood pressure, and gastrointestinal activity that humans commonly associate with stress. These responses have a relatively short duration and may or may not have significant long-term effects on an animal's welfare.

An animal's third line of defense to a stressor involves its neuroendocrine systems, usually hormones associated with the hypothalamus-pituitary-adrenal system (most commonly known as the HPA axis in mammals or the hypothalamus-pituitary-interrenal axis in fish and some

reptiles). Unlike stress responses associated with the autonomic nervous system, virtually all neuroendocrine functions that are affected by stress – including immune competence, reproduction, metabolism, and behavior – are regulated by pituitary hormones. Stress-induced changes in the secretion of pituitary hormones have been implicated in failed reproduction (Rivier 1985; Moberg 1987) and altered metabolism (Elsasser et al. 2000), immune competence (Blecha 2000) and behavior. Increases in the circulation of glucocorticosteroids (cortisol, corticosterone, and aldosterone in marine mammals) are equated with stress.

The primary distinction between stress (which is adaptive and does not normally place an animal at risk) and distress is the biotic cost of the response. During stress, an animal uses glycogen stores that can be quickly replenished once the stress is alleviated. In such circumstances, the cost of the stress response does not pose a risk of the animal's welfare.

However, when an animal has insufficient biotic reserves to satisfy the biotic cost of a stress response, then resources must be shifted away from other biotic functions. When sufficient reserves are diverted from these functions, the functions are impaired. For example, when stress shifts metabolism away from growth, depending on severity of the shift, young animals may no longer thrive and growth may be stunted. When energy is shifted from supporting reproduction, reproductive success may be diminished.

In these cases, animals have entered a pre-pathological state and are experiencing "distress" (sensu Seyle 1950) or "allostatic loading" (sensu McEwen and Wingfield 2003). This period of distress will last until the animal replenishes its biotic reserves sufficient to restore normal function.

Relationships between these physiological mechanisms, animal behavior, and the costs of stress responses have also been documented fairly well through controlled experiment; because this physiology exists in every vertebrate that has been studied, it is not surprising that stress responses and their costs have been documented in both laboratory and free-living animals (Holberton et al. 1996; Hood et al. 1998; Jessop et al. 2003; Lankford et al. 2005).

Studies of other marine animals and terrestrial animals would lead us to expect some marine mammals to experience physiological stress responses and, perhaps, physiological responses that would be classified as "distress" upon exposure to mid-frequency and low-frequency sounds. For example, when bowhead and gray whales were exposed to various types of man-made noise, their surfacings become unusually brief with fewer blows per surfacing (Richardson et al. 1985c; Richardson et al. 1986; Malme et al. 1989; Richardson et al. 1990). These authors concluded that changes in surfacing, respiration, and diving behavior may be indicators of stress, although their consequences on the population ecology of the animals that are affected remain unknown.

Marine mammals naturally experience stressors within their environment and as part of their life histories. Changing weather and ocean conditions, exposure to diseases and naturally occurring toxins, lack of prey availability, social interactions with members of the same species, and interactions with predators all contribute to the stress a marine mammal experiences. In some

cases, naturally occurring stressors can have profound impacts on marine mammals. For example, chronic stress, as observed in stranded animals with long-term debilitating conditions (e.g., disease), has been demonstrated to result in an increased size of the adrenal glands and an increase in the number of epinephrine-producing cells (Clark et al. 2006).

Anthropogenic activities have the potential to provide additional stressors above and beyond those that occur naturally. Stress responses to sound exposures have been studied in other animal species, including humans. Jansen (1998) reported on the relationship between acoustic exposures and physiological responses that are indicative of stress responses in humans (for example, elevated respiration and increased heart rates). Jones (1998) reported on reductions in human performance when faced with acute, repetitive exposures to acoustic disturbance. Trimper et al. (1998) reported on the physiological stress responses of osprey to low-level aircraft noise while Krausman et al. (2004) reported on the auditory and physiology stress responses of endangered Sonoran pronghorn (*Antilocapra americana sonoriensis*) to military overflights. Smith et al. (2004b; 2004a) identified noise-induced physiological stress responses in fish with hearing specializations accompanied with hearing losses. Welch and Welch (1970) reported physiological and behavioral stress responses that accompanied damage to the inner ears of fish and several mammals.

Various efforts have investigated the impact of vessels on marine mammals (both whale-watching and general vessel traffic noise) and demonstrated that impacts do occur (Bain 2002; Erbe 2002b; Williams and Ashe 2006; Noren et al. 2009; Williams and Noren 2009; Pirotta et al. 2015). In analysis of energy costs to killer whales, Williams et al. (2009) suggested that whale-watching in the Johnstone Strait resulted in lost feeding opportunities due to vessel disturbance. Ayres et al. (2012) measured fecal hormones of the Southern Resident DPS killer whales in the Salish Sea to assess the lack of prey (salmon) and vessel traffic on species recovery. Ayres et al. (2012) suggested that the lack of prey overshadowed any population-level physiological impacts on Southern Resident DPS killer whales from vessel traffic.

Marine mammals may exhibit a behavioral response or combinations of behavioral responses upon exposure to anthropogenic sounds. If a sound is detected by a marine mammal, a stress response (e.g., startle or annoyance) or a cueing response (based on a past stressful experience) can occur. Although preliminary because of the small numbers of samples collected, different types of sounds have been shown to produce variable stress responses in marine mammals. Belugas demonstrated no catecholamine (hormones released in situations of stress) response to the playback of oil drilling sounds (Thomas et al. 1990a), but the species has shown an increase in catecholamines following exposure to impulsive sounds produced from a seismic watergun (Romano et al. 2004). A bottlenose dolphin exposed to the same seismic watergun signals did not demonstrate a catecholamine response, but did demonstrate an elevation in aldosterone, a hormone that may be a significant indicator of stress in odontocetes (St. Aubin and Geraci 1989; St. Aubin et al. 2001). Increases in heart rate were observed in bottlenose dolphins to which conspecific calls were played, although no increase in heart rate was observed when take noise

was played back (Miksis et al. 2001). Collectively, these results suggest a variable response that depends on the characteristics of the received signal and prior experience with the received signal.

Other types of stressors include the presence of vessels, fishery interactions, acts of pursuit and capture, the act of stranding, and pollution. In contrast to the limited amount of work performed on stress responses resulting from sound exposure, a considerable larger body of work exists on stress responses associated with pursuit, capture, handling and stranding. A study compared pathological changes in organs/tissues of odontocetes stranded on beaches or captured in nets over a 40-year period (Cowan and Curry 2008). The type of changes observed indicate multi-systematic harm caused in part by an overload of catecholamines into the system, as well as a restriction in blood supply capable of causing tissue damage or tissue death. This response to a stressor or stressors is thought to be mediated by the over-activation of the animal's normal physiological adaptations to diving or escape. Pursuit, capture and short-term holding of belugas have been observed to result in decreased thyroid hormones (St. Aubin and Geraci 1988) and increases in epinephrine (St. Aubin and Dierauf 2001). In dolphins, the trend is more complicated with the duration of the handling time potentially contributing to the magnitude of the stress response (St. Aubin et al. 1996; Ortiz and Worthy 2000; St. Aubin 2002). Male grey seals subjected to capture and short-term restraint showed an increase in cortisol levels accompanied by an increase in testosterone (Lidgard et al. 2008). This result may be indicative of a compensatory response that enable the seal to maintain reproduction capability in spite of stress. Elephant seals demonstrate an acute cortisol response to handling, but do not demonstrate a chronic response; on the contrary, adult females demonstrate a reduction in the adrenocortical response following repetitive chemical immobilization (Engelhard et al. 2002). Similarly, no correlation between cortisol levels and heart/respiration rate changes were seen in harbor porpoises during handling for satellite tagging (Eskesen et al. 2009). Taken together, these studies illustrate the wide variations in the level of response that can occur when faced with these stressors.

In summary, factors to consider when trying to predict a stress or cueing response include the mammal's life history stage, their physical condition at the time of exposure, and whether they are experienced with the stressor. Prior experience with a stressor may be of particular importance as repeated experience with a stressor may dull the stress response via acclimation (St. Aubin and Dierauf 2001). Although, the sound characteristics that correlate with specific stress responses in marine mammals are poorly understood. Therefore, in practice and for the purposes of this opinion, a stress response is assumed if a physical injury such as hearing loss or trauma is predicted; or if a significant behavioral response is predicted.

8.2.5 Masking

Auditory masking occurs when a sound, or noise in general, limits the perception of another sound (Fletcher and Munson 1937). As with hearing loss, auditory masking can effectively limit the distance over which marine mammals can communicate, detect biologically relevant sounds,

and echolocate (odontocetes). Unlike auditory fatigue, which always results in a localized stress response, behavioral changes resulting from auditory masking may not be coupled with a stress response. Another important distinction between masking and hearing loss is that masking only occurs in the presence of the sound stimulus, whereas hearing loss can persist after the stimulus is gone. As a general statement, the more similar the characteristics (i.e., frequency band, duration) of a masking sound are to the sound of interest, the greater its potential for masking.

Acoustic masking from low frequency ocean noise is recognized as a potential threat, especially to low-frequency hearing specialists such as baleen whales (Clark et al. 2009b). Most underwater low-frequency anthropogenic noise is generated by commercial shipping, which has contributed to the increase in oceanic background noise over the past 150 years (Parks et al. 2007a). Shipping noise is primarily in the 20 to 200 Hz frequency band and is increasing yearly (Ross 2005). Andrew et al. (2002) demonstrated an increase in oceanic ambient noise of ten dB sound pressure level since 1963 in the 20 to 80 Hz frequency band as sampled on the continental slope off Point Sur, California, and they ascribed this increase to increased commercial shipping. McDonald et al. (2006a) compared data sets from 1964 to 1966 and 2003 to 2004 for continuous measurements west of San Nicolas Island, California, and found an increase in ambient noise levels of ten to 12 dB sound pressure level in the 30 to 50 Hz band. This increase in low frequency background noise could be having a widespread impact on marine mammal low-frequency hearing specialists by reducing their access to acoustic information essential for con-specific communication and other biologically important activities, such as navigation and prey/predator detection. Clark et al. (2009b) considered this long-term, large-scale increase in low frequency background noise a chronic impact that results in a reduction in communication space, and the loss of acoustic habitat.

Clark et al. (2009b) developed a methodology for estimating masking effects on communication signals for low frequency cetaceans, including calculating the cumulative impact of multiple noise sources. For example, their technique calculates that in Stellwagen Bank National Marine Sanctuary, when two commercial vessels pass through a North Atlantic right whale's (a baleen whale like blue, Bryde's, fin, gray, and humpback whales) optical communication space (estimated as a sphere of water with a diameter of 20 km [11 nmi]), that space is decreased by 84 percent. This methodology relies on empirical data on SLs of calls (which is unknown for many species), and requires many assumptions about ancient ambient noise conditions and simplifications of animal behavior, but it is an important step in determining the impact of anthropogenic noise on animal communication. Subsequent research for the same species and location estimated that an average of 63 to 67 percent of North Atlantic right whale's communication space has been reduced by an increase in ambient noise levels, and that noise associated with transiting vessels is a major contributor to the increase in ambient noise (Hatch et al. 2012).

Vocal changes in response to anthropogenic noise can occur across the repertoire of sound production modes used by marine mammals, such as whistling, echolocation click production,

calling, and singing. Changes to vocal behavior and call structure may result from a need to compensate for an increase in background noise. In cetaceans, vocalization changes have been reported from exposure to anthropogenic noise sources such as sonar, vessel noise, and seismic surveying. Dahlheim et al. (1984) concluded that gray whales in the San Ignacio Lagoon, Baja, California shifted the frequencies of their vocalizations away from the predominant ambient noise producers in the lagoon to overcome masking effects. Biassoni et al. (2001) concluded that the intermittent sounds produced by LFA sonar were unlikely to mask humpback whale songs, but the similarities of its sounds to those produced by the whales could cause some humpback whales to perceive LFA sonar as a competing male. Based on their studies, they concluded that humpback whales could adapt to the presence of LFA sonar and concluded that singing whales could compensate for interference from sound sources like LFA sonar.

Parks et al. (2007a) provided evidence of behavioral changes in the acoustic behaviors of the endangered North Atlantic right whale, and the Southern right whale, and suggested that these were correlated to increased underwater noise levels. The study indicated that right whales might shift the frequency band of their calls to compensate for increased background noise. The significance of their result is the indication of potential species-wide behavioral change in response to gradual, chronic increases in underwater ambient noise. DiLorio and Clark (2010) showed that blue whale calling rates vary in association with seismic sparker survey activity, with whales calling more on days with surveys than on days without surveys. They suggested that the whales called more during seismic survey periods as a way to compensate for the elevated noise conditions.

In the presence of LFA sonar, humpback whales have been observed to increase the length of their ‘songs’ (Miller et al. 2000a; Fristrup et al. 2003), possibly due to the overlap in frequencies between the whale song and the LFA sonar. North Atlantic right whales have been observed to shift the frequency content of their calls upward while reducing the rate of calling in areas of increased anthropogenic noise (Parks et al. 2007a) as well as increasing the amplitude (intensity) of their calls (Parks 2009a). In contrast, both sperm whales and long-finned pilot whales potentially ceased sound production during the Heard Island feasibility test (Bowles et al. 1994), although it cannot be absolutely determined whether the inability to acoustically detect the animals was due to the cessation of sound production or the displacement of animals from the area.

Holt et al. (2009) measured killer whale call SLs and background noise levels in the one to 40 kHz band. The whales increased their call SLs by one dB for every one dB increase in background noise level. A similar rate of increase in vocalization activity was reported for St. Lawrence River beluga whales in response to passing vessels (Scheifele et al. 2005).

Evidence suggests that at least some marine mammals have the ability to acoustically identify potential predators. For example, harbor seals that reside in the coastal waters off British Columbia are frequently targeted by certain groups of killer whales, but not others. The seals discriminate between the calls of threatening and non-threatening killer whales (Deecke et al.

2002), a capability that should increase survivorship while reducing the energy required for attending to and responding to all killer whale calls. The occurrence of masking or hearing impairment provides a means by which marine mammals may be prevented from responding to the acoustic cues produced by their predators. Whether or not this is a possibility depends on the duration of the masking/hearing impairment and the likelihood of encountering a predator during the time that predator cues are impeded.

Like Richardson et al. (1995g), we assume that baleen whales are very sensitive to low-frequency sounds. As a result, masking effects could occur for many of these whales because they vocalize at low frequencies and are thought to have hearing that is sensitive at the SURTASS LFA sonar frequencies. However, masking effects from SURTASS LFA sonar signals will be limited for a number of reasons. First, the bandwidth of any LFA sonar transmitted signal is limited (30 Hz), and the instantaneous bandwidth at any given time of the signal is small, on the order of approximately ten Hz. Therefore, within the frequency range in which masking is possible, the effect will be limited because animals that use this frequency range typically use signals with greater bandwidths. Thus, only a portion of frequency band for the animal's signal is likely to be masked by the LFA sonar transmissions. Furthermore, when LFA sonar is in operation, the LFA sonar source is active only 7.5 to ten percent of the time (based on historical LFA sonar operational parameters), which means that for approximately 92.5 percent of the time, there is no risk that an animal's signal will be masked by LFA sonar. Therefore, within the area in which masking is possible, any effect of LFA sonar transmission will be minimal because of the limited bandwidth and intermittent nature of the signal, and the fact that animals that use this frequency region typically produce signals with greater bandwidth that are repeated for many hours.

The echolocation calls of toothed whales are subject to masking by high frequency sound. However, since echolocation calls occur at much higher frequencies than SURTASS LFA sonar, the extent of upward masking (i.e., low frequencies masking high frequencies) would be limited. Additionally, studies on captive odontocetes by Au et al. (1974; 1985; 1993) indicated that some species may use various processes to reduce masking effects (e.g., adjustments in echolocation call intensity or frequency as a function of background noise conditions). There is also evidence that the directional hearing abilities of odontocetes are useful in reducing masking at the high frequencies used for echolocation, but not at the low-moderate frequencies used for communication (Zaitseva et al. 1980).

Although low frequency hearing has not been studied in many odontocete species, those species that have been tested (beluga whale, killer whale, falser killer whale, Risso's dolphin [*Grampus griseus*], and bottlenose dolphin) exhibit poor audiometric and behavioral sensitivity to low frequency sound. For sounds dominated by low frequency components, the maximum radius of audibility for most odontocete species may often be noise-limited when sensitivity is good, and sensitivity-limited when sensitivity is poor.

Hildebrand (2005a) provided a comparison of anthropogenic underwater sound sources by their annual energy output. On an annual basis, four LFA sonar systems were estimated to have a total energy output of 6.8 x 10^{11} Joules per year. Seismic airgun arrays and mid-frequency military sonars were two orders of magnitude greater, with an estimated annual output of 3.9 and 2.6 x 10^{13} Joules per year, respectively. Super tankers were estimated at 3.7 x 10^{12} Joules per year. Hildebrand (2005a) concluded that anthropogenic sources most likely to contribute to increased underwater noise in order of importance are: commercial shipping, offshore oil and gas exploration and drilling, and naval and other uses of sonar. The percentage of the total anthropogenic acoustic energy budget added by each LFA sonar source is estimated to be 0.21 percent per system (or less), when the other man-made sources are considered (Hildebrand 2005a). When combined with the naturally occurring and other man-made sources of noise in the oceans, the intermittent LFA sonar signals barely contribute a measurable portion of the total acoustic energy.

8.2.6 Stranding

Stranding is a potential risk for cetaceans. Stranding occurs when marine mammals passively (unintentionally) or purposefully come ashore either alive, but debilitated or disoriented, or dead. Although some species of marine mammals, such as pinnipeds, routinely come ashore during all or part of their life history, stranded marine mammals are differentiated by their helplessness ashore and inability to cope with or survive their stranded situation (i.e., they are outside their natural habitat (Geraci and Lounsbury 2005).

Strandings of multiple marine mammals, or mass strandings, occur only rarely. A mass stranding of marine mammals is the stranding of two or more unrelated cetaceans (i.e., not a mother-calf pair) of the same species coming ashore at the same time and place (Geraci and Lounsbury 2005). Mass strandings typically involve pelagic odontocete marine mammal species that occur infrequently in coastal waters and are usually typified by highly developed social bonds. Marine mammal strandings and mortality events are natural events, and such events continue to occur throughout the world’s oceans.

Over the last four decades, marine mammal stranding networks have become established, and the reporting of marine mammal stranding and mortality events has become better documented and publicized. This has led to increased public awareness and concern, especially regarding the potential for anthropogenic causes of stranding and mortality events. Underwater noise, particularly sounds generated by military sonar or geophysical and geologic seismic exploration, has increasingly been implicated as the plausible cause for marine mammal mortality and stranding events. However, despite extensive and lengthy investigations and continuing scientific research, definitive causes or links are rarely determined for the vast majority of marine mammal mass strandings and unusual morality events. It is generally more feasible to exclude causes of strandings or unusual mortality events than to resolve the specific causative factors leading to these events. For instance, although no definitive cause could be identified for the mass stranding and death of 26 short-beaked common dolphins (*Delphinus delphis*) in the Cornwall region of

the United Kingdom during 2008, more than ten factors were excluded as they were considered highly unlikely to have caused the stranding (Jepson and Deaville 2009). Ketten (2014) examined the linkage between mass strandings of marine mammals and exposure to military sonar and other high intensity acoustic sources and noted that, in absence of other causative factors, mid-frequency military sonar transmissions have been implicated as a causative factor in several marine mammal strandings in the Bahamas, Hawaii, the Canary Islands, Madeira, and Greece. Bernaldo de Quirós et al. (2019) reviewed the mass strandings occurring in these areas and suggest that the effects of mid-frequency active sonar on beaked whales vary among individuals or populations, and predisposing factors may contribute to individual outcomes.

As a result of scientific investigations and research over the last decade, especially on beaked whales, scientific understanding has increased regarding the association between behavioral reactions to natural as well as anthropogenic sources and strandings or deaths of marine mammals. Scientists suspect that for some species, particularly deep-diving marine mammals, behavioral reactions may begin a cascade of physiologic effects, such as gas and fat embolisms, that may result in injury, death, and strandings of marine mammals (Fernandez et al. 2005a; Cox et al. 2006; Zimmer and Tyack 2007; Bernaldo de Quirós et al. 2019).

Globally from 2006 through early 2010, at least 27 mass strandings of 11 marine mammal species occurred. These 27 mass stranding and mortality events were researched and analyzed to determine if any occurred within or near SURTASS LFA sonar model areas, or if any were potentially associated with the transmission of underwater sound from military sonar. Any mass strandings involving beaked whales were also examined, as strandings of this species group have been shown to have a significant correlation with MFA naval sonar activities in some geographic regions (in the Mediterranean and Caribbean Seas but not off the coasts of Japan or Southern California) (Filadelfo et al. 2009). Additionally, marine mammal stranding records from Japan were analyzed for spatial or temporal correlations to SURTASS LFA sonar training and testing activities. The use of SURTASS LFA sonar was not associated with any of the reported 27 mass stranding events or unusual mortality events that occurred globally between 2006 and early 2010. There is no evidence that LFA sonar transmissions resulted in any difference in the stranding rates of marine mammals in Japanese coastal waters adjacent to LFA sonar model areas.

For the 2017 through 2019 reporting period, all available media and known stranding databases were monitored for strandings in or adjacent to the SURTASS LFA sonar training and testing activities for vessels in the western and central North Pacific Ocean and Indian Ocean model areas. The Navy concluded that no stranding events occurred spatially and/or temporally with the SURTASS LFA sonar missions. In addition, the Navy concluded that no strandings have occurred coincident to SURTASS LFA sonar in more than sixteen years of its use, and no research indicates that strong avoidance reactions to LFA sonar would occur that would increase the risk of gas bubble formation (Navy 2018a).

8.2.7 Potential Long-Term Consequences to the Individual and the Population

Long-term consequences to a population are determined by examining changes in the population growth rate. Individual effects that could lead to a reduction in the population growth rate include mortality or injury (that removes animals from the reproductive pool), hearing loss (which depending on severity could impact navigation, foraging, predator avoidance, or communication), chronic stress (which could make individuals more susceptible to disease), displacement of individuals (especially from preferred foraging or mating grounds), and disruption of socials bonds (due to masking of conspecific signals or displacement). However, the long-term consequences of any of these effects are difficult to predict because individual experience and time can create complex contingencies, especially for intelligent, long-lived animals like marine mammals. While a lost reproductive opportunity could be a measurable cost to the individual, the outcome for the animal, and ultimately the population, can vary. Any number of factors, such as maternal inexperience, years of poor food supply, or predator pressure, could produce a cost of a lost reproductive opportunity, but these events may be "made up" during the life of a normal, healthy individual. The same holds true for exposure to human-generated noise sources. These biological realities must be taken into consideration when assessing risk, uncertainties about that risk, and the feasibility of preventing or recouping such risks. The long-term consequences or relatively trivial events like short-term masking of a conspecific's social sounds, or a single lost feeding opportunity, can be exaggerated beyond its actual importance by focusing on the single event and not within the larger context of the individual and its lifetime parameters of growth, reproduction, and survival.

Population models are well known from many fields in biology including fisheries and wildlife management. These models accept inputs for the population size and changes in vital rates of the population such as the mean values for survival age, lifetime reproductive success, and recruitment of new individuals into the population. The time-scale of the inputs in a population model for long-lived animals such as marine mammals is on the order of seasons, years, or life stages (e.g., neonate, juvenile, reproductive adult), and are often concerned only with the success of individuals from one time period or stage to the next. Unfortunately, information is not available to accurately assess the impact of acoustic exposure on individual marine mammal vital rates. Further, for assessing the impact of acoustic impacts to marine mammal populations, many of the inputs required by population models are not known.

Recently, efforts have been made to understand the linkage between a stressor, such as anthropogenic sound, and its immediate behavioral or physiological consequences for the individual, and then the subsequent effects on that individual's vital rates (growth, survival, and reproduction), and the consequences, in turn, for the population. In 2005, a panel convened by the National Research Council of the United States National Academy of Sciences published a report on *Marine Mammal Populations and Ocean Noise: Determining When Noise Causes Biologically Significant Effects*. The panel developed what it called "a conceptual model" that outlined how marine mammals might be affected by anthropogenic noise and how population

level effects could be inferred on the basis of observed behavioral changes. They called this model 'Population Consequences of Acoustic Disturbance' (PCAD). In 2009, the U.S. Office of Naval Research (ONR) set up a working group to transform this framework into a formal mathematical structure and determine how that structure could be parameterized using data from a number of case studies. The ONR working group extended the PCAD framework so that it could be used to consider other forms of disturbance and to address the impact of disturbance on physiology as well as behavior. Their current version of that framework is now known as Population Consequences of Disturbance (PCoD) (New et al. 2014). It is important to note that PCoD is ongoing and is an exploratory project to determine how an interim PCoD approach might inform analysis.

New et al. (2013) developed a mathematical model simulating a functional link between feeding energetics and a species' requirements for survival and reproductions for 21 species of beaked whale. The authors report "reasonable confidence" in their model, although approximately 29 percent (six of 21 beaked whale species modeled) failed to survive or reproduce, which the authors attribute to possible inaccuracies in the underlying parameters. Based on the model simulation, New et al. (2013) determined that if habitat quality and "accessible energy" (derived from the availability of either plentiful prey or prey with high energy content) are both high, then survival rates are high as well. If these variables are low, then adults may survive but calves will not. For the 29 percent of beaked whale species for which the model failed (within the assumed range of current inputs), the assumption was a two-year calving period (or inter-calf interval). However, for species with longer gestation periods (such as the 17-month gestation period of Baird's beaked whale [*Berardius bairdii*]), this inter-calf interval may be too short. For Blainville's beaked whale, (Claridge 2013) has shown that calf age at separation is at least three years, and that the inter-calf interval at Abaco in the Bahamas may be four years. New et al. (2013) acknowledge that an assumed two-year calving period in the modeling may not be long enough to build up the energetic resources necessary for mother and calf survival.

As another critical model assumption, prey preferences were modeled based on stomach content analyses of stranded animals, which the authors acknowledge are traditionally poor estimates of the diets of healthy animals, as stranded animals are often sick prior to stranding. Stomach content remnants of prey species do not digest equally, as only the hard parts of some prey types remain (e.g., fish otoliths, beaks of cephalopods) and thus often provide an incomplete picture of diet. Given these unknowns are the failure of the simulation to work for 29 percent of beaked whale species, the modeled survival rates of all beaked whales, particularly those modeled with prey having low energy content, may be better than simulated if higher-energy prey makes up a larger part of the diet than assumed by the model simulations.

In short, for the model output New et al. (2013) created to correctly represent links between the species and their environment, that model must identify all the critical and relevant ecological parameters as input variables, provide the correct values for those parameters, and then the model must appropriately integrate modeling functions to duplicate the complex relationships the

model intends to represent. If an assumption (model input) such as calving period or prey preferences is incorrect (and there is presently no way to know), then the model would not be representing what may actually be occurring. New et al. (2013) report that their simulations suggest that adults will survive but not reproduce if anthropogenic disturbances result in being displaced to areas of "impaired foraging." Underlying this suggestion is the additional unstated assumption that habitat capable of sustaining a beaked whale is limited in proximity to where any disturbance has occurred, and there are no data to indicate that is a valid assumption.

While the New et al. (2013) model provides a test case for future research, this pilot study has very little critical data necessary to form any conclusion applicable to current management decisions. The authors note the need for more data on prey species and reproductive parameters including gestation and lactation duration, as the model results are particularly affected by these assumptions. Therefore, any suggestion of biological sensitivity to the simulation's input parameters is uncertain.

New et al. (2014) used a simulation model to assess how behavioral disruptions (e.g., significant disruption of foraging behavior) may affect Southern elephant seal (*Mirounga leonina*) health, offspring survival, individual fitness, and population growth rate. They suggested their model can determine the population consequences of disturbance from short-term changes in individual animals. Their model assumed that disturbance affected behavior by reducing the number of drift dives in which the animals were feeding and increasing the time they spent in transit. For example, they suggested a disturbance lasting 50 percent of an average annual foraging trip would reduce pup survival by 0.4 percent. If this level of disturbance continued for 30 years and the population did not adapt, the authors found that the population size would decrease by approximately ten percent.

The findings of New et al. (2014) are not applicable to the temporary behavioral disruptions that may be caused by SURTASS LFA sonar for a number of reasons. First, the model assumed that individuals would be unable to compensate for lost foraging opportunities. As described previously, available empirical data does not confirm this would be the case. Additionally, the behavioral disruption of ESA-listed species reasonably expected to occur due to the operation of SURTASS LFA sonar will not have as long of a duration as those considered in the New et al. (2014) study. No individual animals will be exposed to SURTASS LFA sonar for a long enough duration to disrupt 50 percent of its annual feeding opportunities over multiple years. New et al. (2014) suggest it would be unlikely even for episodic environmental change, such as El Niño events, to affect the probability of population persistence. As suggested by the authors, the New et al. (2014) model may be more applicable to the consideration of potential long-term behavioral disruptions (e.g., those that may result from climate change).

In summary, it remains challenging to assess the relative biological significance of, and the potential for long term or population consequences to result from, short-term behavioral responses in marine mammals due to Navy LFA sonar. While it is important to understand the ways in which behavioral responses may result in long-term impacts to individuals or

populations, we do not yet have the data to underpin the link between behavioral response and population consequences (Harris et al. 2017a). Until an appropriate quantitative model is developed and until all relevant empirical data is collected to support such a model for the species considered in this opinion, the best assessment of long-term consequences from Navy SURTASS LFA sonar training and testing activities will be to monitor marine mammal populations over time. A 2010 collaborative Navy workshop on Marine Mammals and Sound indicated a critical need for baseline biological data on marine mammal abundance, distribution, habitat, and behavior over sufficient time and space to evaluate impacts from human-generated activities on long-term population survival(U.S. Navy et al. 2010). The Navy has developed monitoring plans for protected marine mammals and sea turtles occurring on Navy ranges with the goal of assessing the impacts of training and testing activities on marine species and the effectiveness of the Navy's current mitigation practices. All monitoring reports are available to the public and posted online at: www.navymarinespeciesmonitoring.us/.

8.3 Potential Effects of LFA Sonar on Sea Turtles

There are very few studies of the potential effects of underwater sound on sea turtles and most of these examined the effects of sounds of much longer duration or of different types (e.g., seismic airgun) than the SURTASS LFA sonar signals. The analysis of the potential effects on sea turtle species is summarized based on the following SURTASS LFA sonar operational parameters:

- Small number of SURTASS LFA sonar systems to be deployed;
- Geographic restrictions imposed on system employment;
- Narrow bandwidth of the SURTASS LFA sonar signal (approximately 30 Hz);
- Slowly moving ship, coupled with low system duty cycle, would mean that a sea turtle would spend less time in the LFA sonar mitigation and buffer zones (180 dB sound pressure level sound field); therefore, with a ship speed of less than 9 kph (five kt), the potential for animals being in the sonar transmit beam during the estimated 7.5 to 10 percent of the time the sonar is actually transmitting is very low; and
- Small size of the LFA sonar mitigation zone (180 dB sound pressure level sound field) relative to open ocean areas.

Due to the lack of more definitive data on sea turtle species or DPS distributions in the open ocean, it is not feasible to estimate the percentage of a species or DPS that could be located in a SURTASS LFA sonar training and testing activities area at a potentially vulnerable depth, during a LFA sonar sound transmission. Data on sea turtle sound production and hearing are very limited, although they are known to hear low frequency sound (Martin et al. 2012; Lavendar 2014).

8.3.1 Non-Auditory Injury

There is limited data on the potential for anthropogenic sound to cause injury in sea turtles, but direct injuries from SURTASS LFA sonar are unlikely because of the relatively lower peak pressures and slower rise times than potentially injurious sources such as impulsive sounds or

explosives. In their "*Sound Exposure Guidelines for Sea Turtles and Fishes,"* a technical report developed and approved by Accredited Standards Committee S3/SC 1 Animal Bioacoustics, Popper et al. (2014) also concluded that the risk of sea turtles experiencing mortality, potential mortal injury, or recoverable injury was low from exposure to low-frequency sonar.

8.3.2 Hearing Loss

Hearing loss could effectively reduce the distance over which sea turtles can detect biologically relevant sounds. Both auditory trauma (a direct injury discussed above) and auditory fatigue may result in hearing loss, but the mechanisms responsible for auditory fatigue differ from auditory trauma. As discussed previously, hearing loss due to auditory fatigue is also known as threshold shift, a reduction in hearing sensitivity at certain frequencies. Threshold shift is the difference between hearing thresholds measured before and after an intense, fatiguing sound exposure. Threshold shift occurs when hair cells in the ear fatigue, causing them to become less sensitive over a small range of frequencies related to the sound source to which an animal was exposed. The actual amount of threshold shift depends on the amplitude, duration, frequency, and temporal patterns of the sound exposure. No studies are published on inducing threshold shift in sea turtles; therefore, the potential for the impact on sea turtles is inferred from studies of threshold shift in other animals. Given sea turtles best underwater hearing range is from 200 to 400 Hz (Martin et al. 2012; Piniak 2012; Lavendar 2014), the potential exists for diving sea turtles to experience auditory effects from exposure to LFA sonar.

A PTS is a permanent hearing loss at a certain frequency range. PTS is non-recoverable due to the permanent destruction of tissues within the auditory system. The animal does not necessarily become deaf, but requires a louder sound stimulus (relative to the amount of PTS) to detect a sound within the affected frequencies. A TTS is a hearing loss that recovers to the original hearing threshold over a period of time. An animal may not even be aware of a TTS. The animal does not become deaf, but requires a louder sound stimulus (relative to the amount of TTS) to detect a sound within the affected frequencies. TTS may last several minutes to several days, depending on the intensity and duration of the sound exposure that induced the threshold shift (including multiple exposures). There are no published scientific data on permanent or temporary loss of hearing in sea turtles caused by low frequency sound. In their *Sound Exposure Guidelines for Sea Turtles and Fishes*, Popper et al. (2014) determined that if a sea turtle was located far from the sound source, there was a low risk it could experience TTS, and a moderate risk if the animal was located intermediate or close distances to the source. However, it is important to note that Popper et al. (2014) did not state the distances for these risk determinations.

Navy (2017a) developed an auditory weighting function and an exposure function in sound SEL estimate onset TTS and PTS in sea turtles. Both functions estimate the most sensitive hearing of sea turtles at a frequency of approximately 170 Hz, with sensitivity decreasing rapidly at frequencies above and below. For SURTASS LFA sonar operating at frequencies between 100 and 500 Hz, the most protective calculations would utilize auditory weighting and thresholds at 170 Hz. Therefore, the threshold for onset TTS is 200 dB re: 1 μPa^2-sec and onset PTS is 220 dB

re: 1 μPa^2-sec and would be weighted by 0 dB (Navy 2017a). To calculate the distance at which onset TTS and onset PTS might occur from exposure to SURTASS LFA sonar, the length of a nominal LFA transmission (60 seconds) should also be considered. If the assumption is made that all received levels are at the same sound pressure level received level (i.e., the animal and vessel remain at the same distance and depth from each other for an entire minute), the thresholds are lowered by approximately 18 dB ($10 \times \log_{10}$[60 seconds]=17.8). This results in sound pressure level thresholds for onset of TTS and PTS of 182 dB re: 1 μPa (rms) and 202 dB re: 1 μPa (rms), respectively. Based on simple spherical spreading (20logR), sea turtles would need to be within 44 m [143 ft] or 4 m [14 ft], respectively, for the duration of an entire 60-seconds LFA transmission to experience onset of TTS or PTS (Navy 2019).

Additionally, for sea turtles to experience auditory impacts, they would need to swim at approximately 3 kt for the 60-seconds signal of the SURTASS LFA sonar, to match its speed. This speed is faster than average swim speeds of sea turtles, but within the range of their fastest swim speeds. However, the HF/M3 active sonar mitigation measure is able to detect sea turtles within the 180 dB re: 1 μPa (rms) mitigation zone (Navy 2019). Masking

While no masking studies on sea turtles have been conducted, an indirect study looked at the potential for masking by examining sounds in an area known to be inhabited by sea turtles. These underwater sound recordings were made in one of the major coastal foraging areas for juvenile sea turtles (mostly green, Kemp's ridley, and loggerhead sea turtles) in the Peconic Bay Estuary system in Long Island, New York (Samuel et al. 2005). The recording season of the underwater environment coincided with the sea turtle activity season in an inshore area where there is considerable boating and recreational activity, especially during the July to September timeframe. During this time period, received levels at the data collection hydrophone system in the 200 to 700 Hz band ranged from 83 dB re: 1 μPa (rms) up to 113 dB re: 1 μPa (rms). Therefore, during much of the season when sea turtles are actively foraging in New York waters, they are undoubtedly exposed to these levels of noise, most of which is anthropogenic. However, there were no data collected on any behavioral changes in the sea turtles as a consequence of anthropogenic noise or otherwise during this study, so it cannot be stated whether this level of ambient sound would have any physiological and/or behavioral effects on the sea turtles.

As previously discussed, sound likely plays a limited role in a sea turtle's environment. The operation of SURTASS LFA sonar is not expected to result in an extended period of time where masking could occur for sea turtles. At a maximum 20 percent duty cycle for SURTASS LFA sonar (but an average of 7.5 percent), it is anticipated that any masking would be temporary (i.e., at least 80 percent of the time an animal would be able to perceive incoming signals through low frequency sounds). The possibility of effective masking would only occur for environmental sounds that happen during the ping transmission (maximum 100 seconds) and are at, or at least close to, the frequencies in the 30 Hz wide bandwidth signal, during the ten seconds the SURTASS LFA sonar was transmitting in that bandwidth. This indicates biological relevant sounds for individuals in close proximity would only be masked for this short, intermittent,

period of time. Furthermore, SURTASS LFA sonar missions are geographically and temporally dispersed. Additionally, the geographical restrictions imposed on all SURTASS LFA sonar training and testing activities would limit the potential for masking of sea turtles in the vicinity of their terrestrial nesting sites. These factors reduce the likelihood of sources causing significant auditory masking in sea turtles.

8.3.3 Physiological Stress

Sea turtles may exhibit a behavioral response or combinations of behavioral responses upon exposure to anthropogenic sounds. If a sound is detected, a stress response (i.e., startle or annoyance) or a cueing response (based on a past stressful experience) can occur. Sea turtles naturally experience stressors within their environment and as part of their life histories. Changing weather and ocean conditions, exposure to diseases and naturally occurring toxins, lack of prey availability, social interactions with members of the same species, nesting, and interactions with predators all contribute to stress. Anthropogenic activities could provide stressors in addition to those that occur in the absence of human activity.

Immature Kemp's ridley sea turtles show physiological responses to the acute stress of capture and handling through increased levels of the stress hormone corticosterone, along with biting and rapid flipper movement (Gregory and Schmid 2001). We would expect the other sea turtle species considered in this opinion to have a similar physiological stress responses. Olive ridley hatchlings showed heightened blood glucose levels indicating physiological stress due to capture (Zenteno et al. 2008). Repeated exposure to stressors, including human disturbance such as from vessel noise and other anthropogenic sound, may result in negative consequences to the health and viability of an individual or population (Gregory and Schmid 2001). Factors to consider when predicting a stress or cueing response is whether an animal is naïve or has prior experience with a stressor. Prior experience with a stressor may be of particular importance as repeated experience with a stressor may dull the stress response via acclimation (Hazel et al. 2007).

8.3.4 Behavioral Reactions

Little is known about the hearing ability of sea turtles and their response to acoustic disturbance. The response of a sea turtle to an anthropogenic sound will depend on the frequency, duration, temporal pattern, and amplitude of the sound, as well as the animal's physical condition, prior experience with the sound and the context in which the sound is encountered (i.e., what the animal is doing at the time of the exposure). Distance from the sound source and whether it is perceived as approaching or moving away could also affect the way a sea turtle responds. Potential behavioral responses to anthropogenic sound could include startle reactions, disruption of feeding, disruption of migration, changes in respiration, alteration of swim speed, alteration of swim direction, and area avoidance, or displacement.

Sea turtles can travel many kilometers per day in the open ocean, as shown in tagging studies (Papi et al. 1995; Luschi et al. 2003); and the use of magnetic positional information for long-range navigation has been demonstrated in several diverse animals, including sea turtles

(Benhamou et al. 2011; Lohmann et al. 2012). Sea turtles make extensive migrations and movements either for foraging opportunities or to breed. Their migration tracks may extend to thousands of kilometers (Luschi et al. 2006; Allen 2007; Shillinger et al. 2008; Arendt et al. 2012).

Changes in movement patterns or other behaviors due to exposure to a high intensity sound source that causes prolonged displacement of animals from the site of their normal activities could be considered a deleterious effect. Displacement can occur in two dimensions: vertical and horizontal. For example, a sea turtle could move to the surface, where anthropogenic low frequency sound would be weaker, possibly exposing it to a higher degree of predation. As for horizontal displacement, this is probably of greatest importance for non-pelagic sea turtle species (green, hawksbill, olive ridley), for which displacement from preferred benthic habitats could be construed as more serious.

Behavioral responses to human activity have been investigated for only a few species of sea turtles: green and loggerhead (O'Hara and Wilcox 1990; McCauley et al. 2000b); and olive ridley, leatherbacks, loggerhead, and 160 unidentified sea turtles (hard-shell species) (Weir 2007). The work by O'Hara and Wilcox (1990) and McCauley et al. (2000b) reported behavioral changes of sea turtles in response to seismic airguns. O'Hara and Wilcox (1990) reported avoidance behaviors by loggerhead sea turtles in response to airguns with sound levels (received level) of 175 to 176 dB re: 1 µPa (peak-to-peak). McCauley et al. (2000b) reported noticeable increase in swimming behavior for both green and loggerhead sea turtles at received levels of 166 dB re: 1 µPa (peak-to-peak). At 175 dB re: 1 µPa (peak-to-peak) received level, both green and loggerhead sea turtles displayed increasingly erratic behavior (McCauley et al. 2000b). In their "Sound Exposure Guidelines for Sea Turtles and Fishes," Popper et al. (2014) determined that the relative risk of sea turtles responding behaviorally to low-frequency sonar is low, regardless of the distance from the source. Furthermore, given the best available data from airgun exposures, a behavioral response threshold of 175 dB re 1 µPa (rms) based on seismic data was developed by the Navy (Navy 2017a), which is the behavioral harassment threshold used in this opinion for sea turtles. The isopleth for this threshold is approximately equidistant to the 2,000 yd mitigation zone distance. As stated in Section 3.4.2, at 2,000 yd (1.83 km), modeling shows that the sound field would be about 174.75 dB.

It is also possible that behavioral reactions could lead to negative physiological consequences. For example, Garcia-Parraga et al. (2014) reported evidence of decompression sickness (e.g., gas embolism) in sea turtles following capture in trawls or gillnets, with a higher incidence of decompression sickness when caught in deeper waters. A sea turtle could have an extreme behavioral avoidance reaction (e.g., surfacing too quickly in an attempt to avoid noise) that could lead to decompression sickness-like symptoms and fitness consequences. However, previous research has suggested sea turtles are protected against decompression sickness through anatomical, physiological, and behavioral adaptations (Berkson 1967; Lutcavage and Lutz 1997; Piantadosi and Thalmann 2004; Fossette et al. 2010; Castellini 2012). Given this uncertainty in

the available literature and the lack of evidence that this sort of extreme behavioral avoidance reaction would be expected from exposure to SURTASS LFA sonar, we do not believe such a reaction is likely to occur.

8.4 Impacts of Mitigation to Minimize or Avoid Exposure

As described in Sections 3.4 and 3.5, the Navy and NMFS propose several mitigation and monitoring measures to reduce or eliminate the likelihood of exposing marine mammals to LFA sonar transmissions at high decibel levels including a monitoring program (visual monitoring, passive acoustic monitoring, and the HF/M3 active acoustic sonar system), delay/suspension protocols for LFA sonar transmissions, and geographic constraints on the use of SURTASS LFA sonar (coastal mitigation, LFA sonar mitigation and buffer zones, OBIAs, and avoidance of known recreational and commercial dive sites). Below we assess the available information on the effectiveness of the Navy's proposed mitigation measures to minimize adverse effects to ESA-listed species from the proposed action. The Navy states that the employment of the combination of three mitigation monitoring measures at sea results in a predicted effectiveness nearing 100 percent within the 180 dB LFA sonar mitigation zone (Navy 2001a; Navy 2001b; Navy 2007; Navy 2012; Navy 2017b).

8.4.1 Mitigation/Buffer Zone

ESA-listed species could be exposed to sound levels at or above 180 dB and could experience PTS or more serious injury inside the LFA sonar mitigation and buffer zones (now a single 2,000 yd fixed distance) during a ping. However, the single 2,000 yd fixed distance was established and designed to prevent listed species from being exposed to energy levels high enough to produce these outcomes. Several aspects of the LFA sonar mitigation and buffer zones reduce an ESA-listed species' chances of being exposed to LFA sonar at sound pressure levels at or above 180 dB; (a) the mitigation zone extends 2,000 yd from the transmitters encompassing all sound levels at or above 180 dB ; (b) the detection probabilities associated with the HF/M3 sonar (based on SPE) exceed 95 percent for small dolphins at about 750 m (2,460 ft), whale calves at 1,000 m (3,281 ft) and large whales at more than 1,500 m (44,921 ft); (c) during actual training and testing activities marine mammals will receive approximately five pings from the HF/M3 sonar before entering the 180 dB mitigation zone with the probability of detection approaching 100 percent; (d) the depth of the LFA sonar transmitters would reduce the risk of exposing animals located near the ocean's surface or in the mixed layer; and (e) marine mammals have a high probability of being detected within the LFA single 2,000 yd fixed distance and, as a result, a low probability of being exposed to sound pressure levels greater than 175 or 180 dB re: 1 µPa (rms) at 1 m.

For an animal to be exposed to LFA sonar transmissions at sound pressure levels greater than 180 dB, the animal would have to enter the LFA sonar mitigation and buffer zones without being detected by visual observers or the HF/M3 sonar system and would have to remain in the LFA sonar mitigation and buffer zones when LFA sonar transmitters were operating. The monitoring results from deployments of the SURTASS LFA sonar system from August 2002 through June

of 2019 suggest this is unlikely to occur. From August 2002 through June 2019, the active acoustic monitoring (HF/M3 sonar) resulted in a total of 190 possible marine animal contacts that resulted in suspensions of SURTASS LFA sonar training and testing activities in accordance with the terms and conditions of the existing permit. From August 2012 through June 2019, active acoustic monitoring resulted in a total of 60 detections during the 58 missions of the four SURTASS LFA sonar vessels. No contacts were reported within the 180 dB LFA sonar mitigation zone during transmissions, which suggests that no marine mammals were subjected to LFA sonar exposures that might have resulted in injuries. It is possible that a very small percentage of animals went undetected, but monitoring information does not suggest this is likely.

In prior SURTASS LFA sonar rulemakings and program activities, the 180 dB mitigation zone (now proposed to be a single 2,000 yd combined mitigation/buffer zone) was designed to reduce or alleviate the likelihood that marine mammals are exposed to levels of sound that may result in injury (PTS). NMFS (2018a) presents the auditory weighting functions developed for each marine mammal hearing group that reflect the best available data on hearing, impacts of noise on hearing, and data on equal latency. When estimating the onset of injury (PTS), the NMFS (2018a) marine mammal acoustic technical guidance defines weighted thresholds as SELs. To determine what the SEL for each hearing group would be when exposed to a 60-second (length of a nominal LFA transmission or 1 ping), 300 Hz (the center frequency in the possible transmission range of 100 to 500 Hz) SURTASS LFA sonar transmission, the auditory weighting functions must be applied to account for each hearing group's sensitivity. Applying the auditory weighting functions to the nominal LFA sonar signal results in the thresholds increasing by approximately 1.5, 46, 56, 15, and 20 dB for low frequency, mid-frequency, high frequency, phocids underwater, and otariids underwater groups, respectively. Based on simple spherical spreading (20logR), all hearing groups except low frequency cetaceans would need to be within 7 m (22 ft) for an entire LFA sonar ping (60 seconds) to potentially experience PTS. Low frequency cetaceans would be at the greatest distance from the transmitting sonar before experiencing the onset of injury, 41 m (135 ft) for this example. Consequently, the distance at which SURTASS LFA sonar transmissions will be mitigated (2,000 yd) is greater than the PTS distance associated with low frequency cetaceans. Any mitigation measure developed for low frequency cetaceans would be even more protective for any other marine mammals potentially exposed to SURTASS LFA sonar transmissions.

The following calculations illustrate what the received sound pressure level would be at the distance any low frequency cetacean would begin to experience PTS from transmitting LFA sonar. Per NMFS (2018a) acoustic guidance, the low frequency cetacean threshold is 199 dB re: 1 μPa^2-second (weighted). The magnitude of the auditory weighting function at 300 Hz for SURTASS LFA sonar is 1.5 dB, with the equivalent unweighted cSEL value of 200.5 dB re: 1 μPa^2-second. To convert this value into a sound pressure level value, total duration of sound exposure is needed:

$$\text{Sound Pressure Level} = \text{cSEL} - 10 \times \log_{10}(T)$$

Where *T* is the duration in seconds.

Applying the duration of a single ping of SURTASS LFA sonar, or 60 seconds, would result in 17.8 dB being subtracted from the unweighted cSEL value of 200.5 dB, for a sound pressure level of 182.7 dB re: 1 µPa (rms). The mitigation distance to the 182.7-dB re: 1 µP (u) isopleth would be somewhat smaller than that associated with the previously used 180 dB re: 1 µPa (rms) isopleth. If a low frequency cetacean was exposed to two full pings (60 seconds each) of SURTASS LFA sonar, the resulting sound pressure level would be 179.7 dB re: 1 µPa (rms). This exposure is unlikely, as a marine mammal would have to be close to the LFA sonar array (within 41 m [135 ft]) for an extended period, approximately 20 minutes, to experience two full pings.

The received level in this unlikely scenario (179.7 dB re: 1 µPa [rms]) is very close to the 180 dB re: 1 µPa (rms) received level on which previous mitigation measures for SURTASS LFA sonar have been based. However, as mentioned above, the Navy proposes to establish a fixed 2,000 yd combined mitigation/buffer zone. Due to the revised criteria in the NMFS (2018a) marine mammal acoustic technical guidance, this mitigation zone precludes not only PTS, but also almost all TTS and more severe behavioral reactions.

8.4.2 Visual Monitoring

Visual monitoring will occur only during daylight hours, thus its effectiveness is limited to those hours and declines during poor weather conditions and high Beaufort sea state. Visual monitoring methods for marine mammals or sea turtles can only detect a fraction of those animals present since they can only be detected visually during the relatively short period when they are present at the sea surface (Mellinger and Barlow 2003). Also, visual monitoring is highly variable due to the nature of many cetaceans to form large groups and relatively limited spatial and temporal scales of occurrence. In line transect surveys, the range of visual sighting effectiveness (distance from the ship's track, called effective strip width) varies with an animal's size, group size, reliability of conspicuous behaviors (blows), pattern of surfacing behavior, and positions of the observers (which includes the observer's height above the water surface). For most large baleen whales, effective strip width can be about 3 km (1.6 nmi) up through Beaufort sea state six (Buckland and Borchers 1993). This is compared to sea turtles whose effective strip ranges from 50(164 ft) to 250m (820 ft) (McDaniel et al. 2000). The percentage of animals that will pass unseen is difficult to determine, but while observing minke whales, Schweder et al. (1992) estimated that visual survey crews did not detect about half of the animals in a strip width. Palka (1996) and Barlow (1988) estimated that visual survey teams did not detect about 25 percent of the harbor porpoises in a strip width. Given the limitations of visual monitoring, the Navy estimated that the effectiveness of visual monitoring for marine mammals or sea turtles at the sea surface is approximately nine percent (Navy 2001b). Visual detections of marine mammals during SURTASS LFA sonar missions from August 2002 through June 2019 totaled 29 sightings. Throughout the 58 SURTASS LFA sonar missions conducted between August

2012 through June 2019, 19 visual detections of whales, dolphins, a sea turtle, unidentified species, and two schools of tuna resulted from visual monitoring by civilian observers.

8.4.3 Passive Acoustic Monitoring

Passive acoustic monitoring is only effective when marine mammals (particularly cetaceans) are vocalizing or calling underwater. The effectiveness of detection of some marine mammals by passive acoustic monitoring is considered to be higher than visual monitoring. Thomas et al. (1986) and Clark and Fristrup (1997) concluded that the effective strip width and detection rates for passive acoustic monitoring is greater than that for visual monitoring, but the percentage of animals that will be undetected by the methods is unknown. In joint, dedicated, visual and passive acoustic surveys for marine mammals, ten times as many cetacean groups were detected by passive acoustic methods compared to visual methods only (Mcdonald and Moore 2002a; Sirovic et al. 2004; Barlow and Taylor 2005; Rankin et al. 2007). Frequency coverage for this mitigation method using the SURTASS passive acoustic array is between 0 and 500 Hz, so vocalizing animals are more likely to be detected than animals that do not vocalize. This would increase the detection rate of gray, humpback, fin, and blue whales. Passive acoustic monitoring using the SURTASS passive acoustic array is only effective in the same frequency range in which the LFA sonar transmits. The percentage of marine mammals that are undetected by passive acoustic monitoring is unknown. Detections from passive acoustic monitoring of marine mammals during SURTASS LFA sonar missions from 2002 through 2019, totaled 11 detections within the mitigation/buffer zone.

8.4.4 Active Acoustic Monitoring – High Frequency/Marine Mammal Monitoring Sonar

The HF/M3 active sonar system is the most effective measure the Navy uses to detect animals within two km (1.1 nmi) of the projectors. It is capable of operating in all weather conditions and Beaufort sea states as well as daylight and nighttime hours. The Navy developed the HF/M3 active sonar system due to the limitations of visual monitoring and passive acoustic monitoring. Qualitative and quantitative assessments of the HF/M3 system's ability to detect marine mammals of various sizes were verified in 170 hours of at-sea testing. The at-sea testing showed that several detections of a marine mammal by the HF/M3 sonar system would occur before a marine mammal entered the LFA mitigation/buffer zone (Navy 2001b). Stein and Ellison (2001) reported that the detection probability would be near 100 percent for a medium-sized (10 m [33 ft]) marine mammal swimming towards the system. If the HF/M3 system detects animals within the LFA sonar mitigation or buffer zones, the projectors would be shut-down until the animal(s) move out of the mitigation and buffer zones. Combined with the visual monitoring and passive acoustic monitoring protocols, this minimizes the risk of marine mammals being exposed to sound pressure levels at or above 180 dB re: 1 µPa (rms) at 1 m.

The HF/M3 active sonar system monitoring detected 190 marine animals during SURTASS LFA sonar missions from August 2002 through June 2019, and each of these detections resulted in the delay or suspension of SURTASS LFA sonar transmissions. The Navy followed the appropriate protocols and LFA sonar transmissions were suspended or delayed due to mitigation protocols.

As a result, marine mammals that have been detected were not exposed to sonar transmissions at received levels above 180 dB.

In addition, the HF/M3 sonar ramp-up decreases the likelihood an ESA-listed marine species would be exposed to high sound pressure levels from the HF/M3 system itself. Benda-Beckmann et al. (2014) investigated the effectiveness of ramp-up procedures in reducing the area within which changes in hearing thresholds can occur. They modeled the level of sound killer whales were exposed to during a generic sonar operation preceded by different ramp-up schemes. Results indicate that ramp-up procedures reduced the risk of killer whales receiving sounds of sufficient intensity to affect their hearing. The main factors that limited effectiveness of ramp-up in a typical anti-submarine warfare scenario were high SL, rapid moving sonar source, and long silences between consecutive sonar transmissions.

8.5 Exposure Analysis

Here we estimate the potential exposure of ESA-listed species to SURTASS LFA sonar, the only stressor associated with the action that is likely to adversely affect listed species during the proposed activities (See Section 8.1). Our analyses consider the intensity of received levels, the duration of a potential exposure, and how frequently individuals of an ESA-listed marine mammals and sea turtles might be exposed at different received levels. We assumed that exposure to SURTASS LFA sonar, regardless of the sound pressure level, is a pre-requisite for ESA-listed species to be adversely affected by the sonar.

This section describes the conditions under which ESA-listed species could be exposed to LFA sonar based on evaluations of the available information on the potential effects of LFA sonar provided in Sections 8.2 and 8.3 above, and describes potential relationships between differing levels of exposure to LFA sonar and potential effects on ESA-listed species. Therefore, we assume that the potential biological risk associated with exposure to LFA sonar is a function of an animal's exposure to a sound and their response to that exposure that could adversely affect the animal's hearing, behavior, or physiology.

As described previously, the LFA sonar system consists of up to 18 low-frequency acoustic-transmitting projectors that are suspended from a cable beneath a ship. The SL of an individual projector in the LFA sonar array is approximately 215 dB re: 1 µPa (rms) at 1m, and the sound field of the array can never have a sound pressure level higher than that of an individual projector. The typical LFA sonar signal is not a constant tone, but is a transmission of various signal types that vary in frequency and duration (including continuous wave and frequency-modulated signals). The Navy refers to a complete sequence of sound transmissions as a "ping" which can range from between six and 100 seconds (average of 60 seconds), with no more than ten seconds at a frequency. The time between pings will typically range from six to 15 minutes. The Navy has stated that the duty cycle (the ratio of sound "on" time to total time) would not be greater than 20 percent. Based on operations since 2003, the average duty cycle for the LFA sonar system has been between 7.5 and ten percent (Navy 2018a).

8.5.1 Intensity

Sound transmissions are usually measured in terms of sound pressure levels, which are denoted as decibels and which have a reference pressure value of 1 µPa. The logarithmic nature of the dB scale means that each ten dB increase is a ten-fold increase in power (e.g., 20 dB is a 100-fold increase, 30 dB is a 1,000-fold increase). Humans perceive a ten dB increase in noise as a doubling of sound level, or a ten dB decrease in noise as a halving of sound level.

Inside the 2,000 yd LFA sonar mitigation/buffer zone during a ping, a marine mammal and sea turtle could be exposed to sound levels at or above 180 dB re: 1 µPa (rms) at 1 m. As a result, marine mammals could experience PTS or other injury (see Section 8.4.1 for a discussion on how the mitigation/buffer zone relates to thresholds for PTS). However, implementing the 2,000 yd LFA sonar mitigation/buffer zone around the vessel will ensure that no marine mammals are exposed to a sound pressure levels greater than approximately 175 dB re: 1 µPa. As stated in Section 3.4.2, at 2,000 yd (1.83 km), modeling shows that the sound field would be about 174.75 dB re: 1 µPa (rms).

Given the size of the LFA sonar mitigation/buffer zone, the detection probabilities associated with the HF/M3 sonar (above 95 percent probability of detecting small dolphins at about 750 m [0.4 nmi], whale calves at 1,000 m [0.6 nmi], and large whales at more than 1,500 m [0.8 nmi]), and the depth of the transmitters, a marine mammal would have a high probability of being detected within the LFA sonar mitigation/buffer zones and, as a result, a low probability of being exposed to sound levels greater than 180 dB re: 1 µPa (rms) at 1 m. For an animal to be exposed at received levels greater than 180 dB re: 1 µPa (rms), the animal would have to stay within approximately a one km radius sound field of the LFA sonar transmit array (entered at approximate depth of 122 m [400 ft]), would have to enter without being detected, and would have to remain there when the LFA sonar transmitter was operating. Based on the available information, we believe the probability of all of these events occurring, although possible, is extremely low. Further, SURTASS LFA sonar will be operated to ensure that sonar sound fields do not exceed 180 dB re: 1 µPa (rms) within 22 km (12 nmi) of any coastline, including offshore islands, or designated offshore areas that are biologically important for marine mammals outside the 22 km (12 nmi) zone during seasons specified for a particular area.

Thus far, the combination of monitoring and mitigation measures (including shut-down procedures) appear to have prevented most ESA-listed species of marine mammals and sea turtles from being exposed to SURTASS LFA sonar at received levels exceeding 180 dB (Navy 2018a; Navy 2019). Further, the implementation of geographic restrictions (i.e., coastal and dive sites as well as OBIAs for marine mammals) have prevented ESA-listed species from being exposed in some areas that are important to their ecology, important for large portions of their populations, or both. The Navy proposes to continue using these measures in the prescribed manner. Therefore, based on the evidence available, we consider it very unlikely for an ESA-listed marine animal to experience PTS because we do not expect individuals to be exposed to received levels of LFA sonar at or above 180 dB re: 1 µPa (rms).

8.5.2 Exposure Duration

The Navy proposes to transmit a maximum of 496 total hours of LFA sonar transmissions per year pooled across all SURTASS LFA sonar-equipped vessels in the first four years of the authorization period, with increased sonar usage of a maximum of 592 total hours of LFA sonar transmissions in Year 5 through 7 and continuing into the foreseeable future, regardless of the number of vessels. Currently, the Navy is authorized up to 1,020 hours of LFA sonar transmission per year for all vessels.

The total acoustic energy output of individual sources was considered in calculating an annual noise energy budget in energy units of Joules (Hildebrand 2005b). Commercial supertankers were estimated to contribute 3.7×10^{12} Joules of acoustic energy into the marine environment each year (Joules/yr); seismic airguns were estimated to contribute 3.9×10^{13} Joules/yr; and mid-frequency military sonar was estimated to contribute 2.6×10^{13} Joules/yr (Hildebrand 2005b). Scaling the calculations in Hildebrand (2005) to account for the proposed transmission hours, the contribution from 496 hours of LFA sonar transmissions would be 2.0×10^{11} Joules/yr and the contribution from 592 hours of LFA sonar transmissions would be 2.3×10^{11} Joules/yr. The percentage of the total anthropogenic acoustic energy budget added by LFA sonar source transmissions is estimated to be 0.29 and 0.34 percent, respectively, for years 1-4 and year 5 and beyond (Hildebrand 2005b).

In addition, the duration of a typical SURTASS LFA sonar ping would range from six to 100 seconds, with no more than ten seconds at a single frequency; intervals between pings would range from six to 15 minutes. Pings would consist of various signal types that vary in frequency (between 100 and 500 Hz) and duration (including continuous wave and frequency-modulated signals). When the system is turned off, no additional energy would enter the ocean's environment. The duration of an animal's exposure to SURTASS LFA sonar signals will depend on their proximity to the transmitter and their location in the water column. Because of the length of individual pings, individual animals could be exposed to SURTASS LFA sonar transmissions for periods ranging from six to 100 seconds at a time (at sound pressure levels less than 180 dB), though this assumes the animal would not move away from the sound source in order to avoid exposure.

8.5.3 Exposure Frequency

Individual animals or groups of animals have a low probability of being exposed to SURTASS LFA sonar signals on multiple, separate occasions. The number of times an animal could be exposed to sound from SURTASS LFA sonar transmissions will depend on the deployment schedule for SURTASS LFA sonar vessels and the movement patterns of individual animals.

Some individuals may be exposed to multiple anthropogenic sound-producing activities over a season, year, or life stage. As discussed in Section 8.2, repeated exposure to acoustic and other anthropogenic stimuli on marine mammals has been studied in several cases, especially as related to vessel traffic and whale watching. Common dolphins (Dephinus spp.) in New Zealand

responded to dolphin-watching vessels by interrupting foraging and resting bouts, and took longer to resume behaviors in the presence of the vessel (Stockin 2008). Bejder et al. (2006a) studied responses of bottlenose dolphins to vessel approaches and found shorter lasting reactions in populations exposed to higher levels of vessel traffic. The authors indicated that lesser reactions in populations of dolphins regularly subjected to high levels of vessel traffic could be a sign of habituation, or it could be that the more sensitive animals in this population previously abandoned the area of higher human activity.

Marine mammals exposed to high levels of human activities may leave the area, habituate to the activity, or tolerate the disturbance and remain in the area. Individual marine mammals that are more tolerant may stay in a disturbed area, whereas individuals that are more sensitive may leave for areas with less human disturbance. Animals that remain throughout the disturbance may be unable to leave the area for a variety of physiological or environmental reasons. However, given the highly migratory, wide-ranging life histories, and open ocean environments of the species considered at risk in this consultation, we do not believe animals will remain in the general area of the sound source during SURTASS LFA sonar training and testing activities. Longer-term displacement can lead to changes in abundance or distribution patterns of the species in the affected region if they do not become acclimated to the presence of the sound (Bejder et al. 2006b; Blackwell et al. 2004b; Teilmann et al. 2006). For example, gray whales in Baja California abandoned a historical breeding lagoon in the mid-1960s due to an increase in dredging and commercial shipping operations. Whales did not repopulate the lagoon after shipping activities had ceased for several years (Bryant et al. 1984). Over a shorter time scale, studies on the Atlantic Undersea Test and Evaluation Center instrumented range in the Bahamas have shown that some Blainville's beaked whales may be resident during all or part of the year in the area, and that individuals may move off of the range for several days during and following a sonar event. However animals are thought to continue feeding at short distances (a few km) from the range out of the louder sound fields (less than 157 dB re: 1 µPa (rms)) (McCarthy et al. 2011; Tyack et al. 2011). Mysticetes in the northeast tended to adjust to vessel traffic over a number of years, trending towards more neutral responses to passing vessels (Watkins 1986a) indicating that some animals may habituate or otherwise learn to cope with high levels of human activity. Nevertheless, the long-term consequences of these habitat utilization changes are unknown, and likely vary depending on the species, geographic areas, and the degree of acoustic or other human disturbance.

Moore and Barlow (2013) have noted a decline in beaked whales in a broad area of the Pacific Ocean area out to 556 km (300 nmi) from the coast and extending from the Canadian-U.S. border to the tip of Baja Mexico. There are scientific caveats and limitations to the data used for that analysis, as well as oceanographic and species assemblage changes not thoroughly addressed in Moore and Barlow (2013), although the authors suggest Navy MFA sonar as one possible explanation for the apparent decline in beaked whale numbers over that broad area. In the small portion of the Pacific coast overlapping the Navy's Southern California Range Complex, long-term residency by individual Cuvier's beaked whales and documented higher densities of beaked

whales provide indications that the proposed decline in numbers elsewhere along the Pacific coast is not apparent where the Navy has been intensively training with MFA sonar and other systems for decades. While it is possible that a downward trend in beaked whales may have gone unnoticed at the range complex (due to a lack of survey precision) or that beaked whale densities may have been higher before the Navy began using MFA sonar more than 60 years ago, there are no data available to suggest that beaked whale numbers have declined on the range where Navy sonar use has routinely occurred. As Moore and Barlow (2013) point out, it remains clear that the Navy range in southern California continues to support high densities of beaked whales. Furthermore, a large part of the U.S. West Coast action area used by Moore and Barlow (2013) in their assessment of possible reasons for the decline include vast areas where the Navy does not conduct in-water training with MFA sonar.

Establishing a causal link between anthropogenic noise, animal communication, and individual impacts, as well as population viability, is difficult to quantify and assess (McGregor 2013; Read et al. 2014b). Assessing the effects of sounds, both individually and cumulatively, on marine species is difficult because responses depend on a variety of factors including age class, prior experience, physical condition, behavioral state at the time of exposure, and indirect effects. Responses may be also be influenced by other non-sound related factors (Kight and Swaddle 2011; Ellison et al. 2012a; Goldbogen et al. 2013b; Read et al. 2014b; Williams et al. 2014). McGregor (2013) summarized sound impacts and described two types of possible effects based on the studies they reviewed: (1) an apparent effect of noise on communication, but with a link between demonstrated proximate cost and ultimate cost in survival or reproductive success being inferred rather than demonstrated, and (2) studies showing a decrease in population density or diversity in relation to noise, but with a relationship that is usually a correlation, so factors other than noise or its effect on communication might account for the relationship. Within the ocean environment, aggregate anthropogenic impacts have to be considered in the context of natural variation and climate change (Boyd and Hutchins 2012). These contexts can include additive effects from two or more factors, multiplicity where response from two or more factors is greater than the sum of individual effects, synergism between factors and response, antagonism as a negative feedback between factors, acclimation as a short-term individual response, and adaptation as a long-term population change (Boyd and Hutchins 2012). To address aggregate impacts and responses from any changes due to processes such as habituation, tolerance, and sensitization, future experiments over an extended period of time still need further research (Bejder et al. 2009; Blickley et al. 2012; Read et al. 2014b).

Some, including Goldbogen et al. (2013b) and Stockin et al. (2008) have speculated that repeated interruptions of a marine mammal's normal activity could lead to fitness consequences and eventually, long-term implications for the population. However, to our knowledge, empirical data has not confirmed this to be the case. For example, Goldbogen et al. (2013b) suggested that if a blue whale responded to MFA sonar by temporarily interrupting feeding behavior, this could have impacts on individual fitness and eventually, population health. However, for this to be true, we would have to assume that an individual whale could not compensate for this lost

feeding opportunity by either immediately feeding at another location, by feeding shortly after cessation of acoustic exposure, or by feeding at a later time. There is no indication this is the case, particularly since unconsumed prey would still be available in the environment following the cessation of acoustic exposure.

If sound exposure were to be concentrated in a relatively small geographic area over a long period of time, it would be possible for individuals confined to a specific area to be exposed to acoustic stressors (e.g., LFA sonar) multiple times during a relatively short time period. However, we do not expect this to occur as we would expect individuals to move and avoid areas where exposures to acoustic stressors are at higher levels (e.g., greater than 120 dB). For example, Goldbogen et al. (2013b) indicated some horizontal displacement of deep foraging blue whales in response to simulated MFA sonar[15]. Given these animal's mobility and large ranges, we would expect these individuals to temporarily select alternative foraging sites nearby until the exposure levels in their initially selected foraging area have decreased. Therefore, even temporary displacement from initially selected foraging habitat is not expected to impact the fitness of any individual animals because we would expect equivalent foraging habitat to be available in close proximity. Because we do not expect any fitness consequences from any individual animals, we do not expect any population level effects from these behavioral responses.

8.5.4 Exposure Estimates

Marine Mammals

Under the proposed seven-year MMPA rule, the Navy may operate in the western and central north Pacific and eastern Indian Oceans. It is not feasible for the Navy to estimate take of all marine mammal species and stocks for the whole action area. For this reason, the Navy selected the 15 model areas (see Table 1) previously described that are representative of the different geographic locations where the Navy may operate SURTASS LFA sonar over the next seven years. In each of these mission areas, the Navy estimated take of marine mammal species for a single 24-hour transmission in that location using the density estimates listed in Table 4.

The total take estimates during a representative 24-hour exposure scenario by Level B harassment (behavior and TTS) by percentage of the marine mammal stock affected for mission areas 1 to 15 are described in section 3.5.

As stated, NMFS' Permits and Conservation Division proposes to issue a single LOA to the Navy for all seven years of SURTASS LFA training and testing activity from August 13, 2019 to August 12, 2026. The Navy can only predict the level and general location (i.e., model areas) of SURTASS LFA sonar training and testing activities to inform the amount of exposures from the proposed action. However, this consultation considered the upper limits of potential takes of

[15] It is important to note that effects of MFA sonar should not be directly extrapolated to effects of LFA sonar, however given the small amount of behavioral response studies on LFA sonar, MFA sonar was used as a surrogate.

marine mammals for the duration of the MMPA rule/LOA and into the reasonably foreseeable future. If the Navy were to propose to operate SURTASS LFA sonar in different locations (i.e., missions areas) from those proposed and consistent with the framework established in the proposed MMPA rule, such a change would require additional consultation under section 7 of the ESA.

Under the LOA, the Navy proposes to operate in the areas presented in Figure 2. Modeling to determine impacts from exposure to LFA sonar transmissions on marine mammals was based on the steps listed below. Note these are discussed in further detail in Section 2.1.1 and Chapter 4 of Navy (2018b).

1. First, the potential impact for one LFA sonar transmission hour was calculated.
2. Second, the number of LFA sonar transmission hours that may occur in each model area for each activity is determined.
3. The third step is to determine the number of model areas in which each DPS/stock may occur for each activity, and;
4. The fourth step is to select the maximum per-hour impact for each stock that may occur in the model areas for that activity. The final step is to multiply the results of steps two, three, and four to calculate the potential annual impacts per activity, which are then summed across the stocks for a total potential impact for all individual activities.

The total number of exposure estimates for each ESA listed species affected by SURTASS LFA sonar are presented below, while Table 4 presents the density estimates used for ESA listed species within each of the model areas. The annual ESA takes by harassment (TTS and behavioral) are detailed in Table 14,

Table 15 and Table 16 below. These ESA takes match the MMPA Level B take numbers shown in Table 8, Table 9, Table 10 as both were derived from and rely on best available science incorporated into the Navy's modeling methods presented in Section 2.1.1. For the purposes of this consultation, any action that amounts to incidental harassment of marine mammals under the MMPA—whether TTS or behavioral harassment—constitutes an incidental "take" under the ESA and must be authorized by the Incidental Take Statement (See Section 12). It is important to note that SURTASS LFA sonar has the potential to affect any or all life stages, genders, or age groups of ESA listed marine mammals present in the action area.

Table 14. Estimated annual exposures of ESA-listed species to SURTASS LFA sonar for years 1 to 4 during SURTASS LFA sonar training and testing activities.

ESA-Listed Marine Mammal Species	*DPS/Rangewide*	*Annual ESA Take (TTS and Behavior)*
Blue whale	Rangewide	94

ESA-Listed Marine Mammal Species	*DPS/Rangewide*	*Annual ESA Take (TTS and Behavior)*
Fin whale	Rangewide	2,592
Humpback whale	Western North Pacific DPS	3,103
North Pacific right whale	Rangewide	89
Sei whale	Rangewide	3,195
Gray whale	Western North Pacific DPS	0
False killer whale	Main Hawaiian Islands Insular stock and DPS	1
Sperm whale	Rangewide	1584
Hawaiian monk seal	Rangewide	10
Spotted seal	Southern DPS	0
Western Steller sea lion	Western DPS	2

Table 15. Estimated annual exposures of ESA-listed species to SURTASS LFA sonar for years 5 to 7 during SURTASS LFA sonar training and testing activities.

ESA-Listed Marine Mammal Species	*DPS/Rangewide*	*Annual ESA Take (TTS and behavior)*
Blue whale	Rangewide	129
Fin whale	Rangewide	3,501

ESA-Listed Marine Mammal Species	*DPS/Rangewide*	*Annual ESA Take (TTS and behavior)*
Humpback whale	Western North Pacific DPS	4,266
North Pacific right whale	Rangewide	122
Sei whale	Rangewide	4,388
Gray whale	Western North Pacific DPS	1
False killer whale	Main Hawaiian Islands Insular stock and DPS	1
Sperm whale	Rangewide	2049
Hawaiian monk seal	Rangewide	13
Spotted seal	Southern DPS	1
Western Steller sea lion	Western DPS	3

Table 16. Estimated annual exposures of ESA-listed species to SURTASS LFA sonar for all 7 years of SURTASS LFA sonar training and testing activities.

ESA-Listed Marine Mammal Species	*DPS/Rangewide*	*Total ESA Take for all 7 Years*
Blue whale	Rangewide	763
Fin whale	Rangewide	20,871

ESA-Listed Marine Mammal Species	DPS/Rangewide	Total ESA Take for all 7 Years
Humpback whale	Western North Pacific DPS	25,210
North Pacific right whale	Rangewide	722
Sei whale	Rangewide	25,944
Gray whale	Western North Pacific DPS	3
False killer whale	Main Hawaiian Islands Insular stock and DPS	7
Sperm whale	Rangewide	12,483
Hawaiian monk seal	Rangewide	79
Spotted seal	Southern DPS	3
Western Steller sea lion	Western DPS	17

Sea Turtles

As discussed, the Navy did not use AIM to assess the exposure of sea turtles to SURTASS LFA sonar. Sea turtles are highly migratory species whose complex spatial population structures present challenges for management and conservation efforts. Although life history patterns are broadly defined, much about the demographics, abundance, and distribution of Pacific populations remains unresolved (Becker et al. 2019). Due to a lack of sea turtle density data in the open ocean environment where SURTASS LFA sonar operates, we do not have enough information available to estimate the number of sea turtles that will be exposed to SURTASS LFA sonar and potentially be affected by that exposure. However, juvenile and adult stages of sea turtles could be exposed to SURTASS LFA sonar transmission when residing in pelagic environments. The Navy's HF/M3 system is able to detect sea turtles within the 2,000 yd mitigation/buffer zone (Navy 2018a). We assume that the monitoring protocols associated with SURTASS LFA sonar would be more effective with larger sea turtles, such as adult leatherback and loggerhead sea turtles, than with smaller species such as green, hawksbill, and olive ridley turtles or smaller individual leatherback or loggerhead sea turtles. Monitoring measures may not detect some smaller sea turtles, which would increase their risk of exposure to sound pressure levels associated with SURTASS LFA sonar within the mitigation zone if they encountered SURTASS LFA sonar vessels during sonar transmission. However, due to the small size of the

LFA sonar mitigation/buffer zone relative to the enormous area and volume of the ocean and water column usage by sea turtles (i.e., indicating a low likelihood of co-occurrence), and the three-part monitoring system, sea turtles are unlikely to be exposed to SURTASS LFA sonar transmission levels within the 2,000 yd mitigation zone for SURTASS LFA sonar training and testing activities. For instance, in 2011, a sea turtle was observed by visual observers aboard the USNS *EFFECTIVE* at a distance of about 15 m (49 ft) from the vessel over eight minutes after LFA sonar transmissions ceased. Due to the proximity to the vessel, an assessment was made to determine the potential for the sea turtle to be within the previous LFA mitigation zone (180 dB sound field) and to determine whether the HF/M3 sonar should have detected the sea turtle. Based on the position of the HF/M3 sonar above the LFA vertical line array, the sea turtle would have had to dive from the surface through the HF/M3 sonar detection zone prior to entering into the 180 dB LFA sonar mitigation zone, making the potential for an acoustic detection of the sea turtle highly likely. The lack of detection by the HF/M3 sonar would indicate that the sea turtle remained at or near the surface and did not dive into the 180 dB LFA sonar mitigation zone during transmissions. Thus, it is improbable that the sea turtle was exposed to SURTASS LFA sonar at or above 180 dB re: 1 µPa (rms). It is more probable that sea turtles could be exposed to SURTASS LFA sonar outside of the mitigation zone.

Since under the proposed action, the Navy may operate in portions of the western and central north Pacific and eastern Indian Oceans, any sea turtle species that reside in these areas could be exposed to and affected by SURTASS LFA sonar. This includes all sea turtle species and DPSs considered in this opinion (Table 12).

The Navy can only predict the level and general location (i.e., model areas) of SURTASS LFA sonar training and testing activities. However, these levels and locations have changed minimally since 2002. Based on the Navy's operational history, this consultation assumes that the Navy's SURTASS LFA sonar training and testing activities will continue to be used in these same mission areas into the reasonably foreseeable future. Therefore, we expect that the sea turtle species that occur in the action may be exposed to SURTASS LFA sonar throughout the duration of the Navy's proposed action.

As described previously, we do not have information available that would allow us to estimate the number of sea turtles of each species exposed to, and potentially affected by, SURTASS LFA sonar. However, because a sea turtle would need to remain within 4 m (14 ft) of the LFA sonar for an entire 60-seconds signal without being detected to experience PTS (see Section 8.3.2 for additional detail), the small size of the LFA sonar mitigation zone relative to the enormous area and volume of the ocean and water column usage by sea turtles (i.e., indicating a low likelihood of co-occurrence), and the three-part monitoring system which is expected to detect some sea turtles (Navy 2018a), particularly larger individuals in close proximity, the sea turtle species/DPSs listed in Section 6 are unlikely to be exposed to SURTASS LFA sonar transmission levels that could cause PTS.

Individual sea turtles in the SURTASS LFA sonar 2,000 yd mitigation zone are expected to experience behavioral harassment due to exposure to SURTASS LFA sonar. As explained in section 2.1.2, due to the lack of more definitive data on sea turtle abundance or density in the open ocean, it is not feasible to estimate the percentage of each sea turtle species or DPS (or number of individuals) that could be located in the proposed 2,000 yd mitigation zone during sonar transmission. For this reason and in accordance with 80 FR 26832, we will use a habitat surrogate approach to express the extent of anticipated incidental take of ESA-listed sea turtles from the operation of SURTASS LFA sonar[16]. Due to the mitigation and monitoring procedures that will be implemented by the Navy, we expect some sea turtles will be detected if they were to occur within the 2,000 yd mitigation zone. However, detection rates are not expected to be 100 percent due to the small size of some sea turtles (i.e. juveniles). Any turtles exposed to sound pressure levels at 175 dB re: 1 µPa (rms) (i.e., the level for behavioral harassment of sea turtles as stated in Section 8.3.4) or greater would be expected to exhibit erratic behavior indicating the animal was in an agitated state (McCauley et al. (2000b)).

For sea turtles that will potentially be exposed to SURTASS LFA sonar training and testing activities, the habitat surrogate used for the extent of take in this opinion is the area of the water column exposed to sound pressure levels that would potentially result in TTS and behavioral harassment of sea turtles (The only form of take authorized for sea turtles in this opinion). This area begins at a distance greater than four meters [14 feet] from the LFA sonar sound source and extends to the outer extent of the 2,000 yd mitigation zone. As stated in Section 8.3.2, the area less than four meters from the transmitting LFA sonar sound source is the area of the water column in which a sea turtle could be exposed to PTS sound levels if it were present in the location longer than 60 seconds during SURTASS LFA sonar deployment. It is extremely unlikely for a sea turtle to go undetected at a distance of four meters from the LFA sonar sound source for 60 seconds or longer, therefore PTS of sea turtles is not likely to occur. Due to this, NMFS believes the risk of exposure to PTS for turtles is so low as to be discountable, therefore, no take in the form of PTS is authorized (See Section 12.1). For TTS, sea turtles would need to remain within 44 meters (144 ft) of the LFA sonar sound source for an entire 60-second sonar signal without being detected to experience temporary auditory effects (see Section 8.3.2 for additional detail). Given that the SURTASS LFA sonar vessels operate at a speed of ~3 to 4 knots, the small size of the impact zone, and the general effectiveness of the three-part monitoring system, it is expected that sea turtles, particularly larger individuals, would likely be detected in close proximity to the source. However, it is possible that smaller turtles may not be fully detected and could be exposed to sound levels that have the potential to cause TTS. While we believe the probability of any sea turtle, including smaller ones, experiencing TTS is low,

[16] 80 FR 26832 amended § 402.14(i)(1)(i) of the Code of Federal Regulations to clarify that surrogates may be used to express the amount or extent of anticipated take, provided the biological opinion or the incidental take statement: (1) Describes the causal link between the surrogate and take of the listed species; (2) describes why it is not practical to express the amount of anticipated take or to monitor taker elated impacts in terms of individuals of the listed species; and (3) sets a clear standard for determining when the amount or extent of the taking has been exceeded.

because it cannot be completely ruled out, we are authorizing take of sea turtles in the form of TTS harassment.

Based on the habitat surrogate described above, approximately 10.5 km^2 of sea turtle habitat could be impacted by TTS and behavioral harassment levels of exposure any time SURTASS LFA sonar is transmitted into the water column. This is due to characteristic of SURTASS LFA sonar signals, which have an omnidirectional beam pattern that can impact all surrounding habitat in a 360 degree radius. In all, the extent of take for sea turtle habitat that could be exposed by incidental take (TTS and behavioral harassment) from SURTASS LFA sonar training and testing activities is shown in Table 17 below. As indicated in Table 17, the area in which ESA harassment could occur at any one time during the transmission of the LFA sonar, relative to the potential habitat available to the animal during the same time period, is extremely small. Only 0.00002 percent to 0.0001 percent of the available habitat at any one time could be affected by SURTASS LFA sonar transmissions that could cause take by ESA harassment of sea turtles.

Table 17 Estimated Area of Sea Turtle Habitat Affected by ESA Harassment (TTS and Behavioral) During SURTASS LFA Sonar Training and Testing Activities When Sonar is Transmitting.

Species (DPS or Rangewide)	Total Habitat Affected	Total Estimated Area of Habitat	Percentage of Habitat Affected
Green Sea Turtle (Central North Pacific DPS)[1]	10.5 km^2	9,761,217 km^2	0.0001%
Green Sea Turtle (Central West Pacific DPS) [1]	10.5 km^2	21,033,760 km^2	0.00005%
Green Sea Turtle (East Indian/West Pacific DPS) [1]	10.5 km^2	28,597,221 km^2	0.00004%
Green Sea Turtle (North Indian DPS) [1]	10.5 km^2	8,808,658 km^2	0.0001%
Loggerhead Sea Turtle (North Indian Ocean DPS) [1]	10.5 km^2	8,488,864 km^2	0.0001%
Loggerhead Sea Turtle (North Pacific Ocean DPS) [1]	10.5 km^2	69,466,810 km^2	0.00002%

Loggerhead Sea Turtle (Southeast Indo-Pacific DPS) [1]	10.5 km^2	10,227,916 km^2	0.0001%
Hawksbill Sea Turtle (Rangewide)[2]	10.5 km^2	46,721,570 km^2	0.00002%
Leatherback Sea Turtle[2]	10.5 km^2	67,596,448 km^2	0.00002%
Olive Ridley Sea Turtle[2]	10.5 km^2	56,072,847 km^2	0.00002%

[1]The total estimated area of habitat for green and loggerhead sea turtle DPSs is based on approximate species range data presented on https://www.fisheries.noaa.gov/species/. The boundaries used to determine the extent of DPS ranges for loggerhead and green sea turtles were presented in 76 FR 58867 and 81 FR 20057, respectively.

[2]For sea turtle species with rangewide ESA-listings, the total estimated area of habitat is based on the total area of species habitat located in the SURTASS LFA action area. Sea turtle ranges were based on approximate species range data presented on https://www.fisheries.noaa.gov/species/.

8.6 Response Analysis

The Potential Effects Section for SURTASS LFA sonar (Section 8.2) discussed the potential responses of marine mammals to exposure to SURTASS LFA sonar. Based on the literature presented in these sections and the exposure estimates discussed in 8.5.4 and presented in Table 8, Table 9, Table 10, Table 14,

Table 15 and Table 16, this section details our conclusions on the response of marine mammals to exposure to SURTASS LFA sonar. The response analysis presented below is applicable to exposures that could occur for the duration of the proposed seven-year MMPA rule and issuance of the LOA.

8.6.1 Marine Mammals

8.6.1.1 *Mysticetes*

As discussed previously, based on the performance of the SURTASS LFA sonar system and the mitigation measures the Navy has used with the SURTASS LFA sonar system over the past 17 years (2002 through 2019), it is unlikely that any baleen whales (blue, fin, gray, humpback, North Pacific right, or sei whales) would be exposed to received levels equal to or greater than 180 dB re: 1 µPa (rms) (or even 175 dB re: 1 µPa (rms) considering the buffer zone that will be implemented). The available evidence (presented in section 8.2) suggests that at received levels below 180 dB re: 1 µPa (rms), exposure to LFA sonar transmissions is not likely to result in injury, significant masking, stranding, resonance effects, or long-term behavioral effects in

marine mammals. The best scientific and commercial data available (presented in section 8.2) suggest that mysticetes exposed to SURTASS LFA sonar may react behaviorally or experience TTS. However, many mysticetes exposed may not experience TTS or respond at all. Since SURTASS LFA sonar operates at a frequency between 100 and 500 Hz, mysticetes are expected to be able to hear SURTASS LFA sonar if exposed (NMFS 2018a). Below we discuss the likely responses of mysticetes to exposures that could result in TTS or behavioral response and the potential for these exposures to result in fitness consequences to individual animals.

For TTS, full recovery of the hearing loss (to the pre-exposure threshold) has been determined from studies of marine mammals, and this recovery occurs within minutes to hours for the small amounts of TTS that have been experimentally induced (Nachtigall et al. 2004; Finneran et al. 2005; Finneran and Schlundt 2010). The recovery time is related to the exposure duration, SEL, and the magnitude of the threshold shift, with larger threshold shifts and longer exposure durations requiring longer recovery times (Finneran et al. 2005; Mooney et al. 2009a; Mooney et al. 2009b; Finneran and Schlundt 2010). For an animal to experience a large threshold shift, it would have to approach close to the sonar source or remain in the vicinity of the sound source for an extended period of time. We would not expect this to be the case due to the mitigation and monitoring measures implemented by the Navy, the low duty cycle of SURTASS LFA sonar, and that both the animal and vessel would be moving (most likely not in the same direction). Additionally, though the frequency range of TTS that mysticetes are likely to sustain would overlap with some of the frequency ranges of their vocalization types, the frequency range of TTS from SURTASS LFA sonar would not usually span the entire frequency range of one vocalization type, much less span all types of vocalizations or other critical auditory cues. Given the brief amount of time mysticetes are expected to experience TTS and the limited frequency range in which this TTS is expected to occur, it is unlikely to significantly impair their ability to communicate, forage, or breed and will not have fitness level consequences at the individual level. Because we do not expect any fitness consequences from any individual animals to result from instances of TTS, we do not expect any population (stock or DPS) level effects from instances of TTS.

Section 8.2.3 presented a detailed discussion on the potential behavioral responses of marine mammals following exposure to low-frequency sound sources (including low frequency active sonar). As stated in that section, all behavioral reactions are assumed to occur due to a preceding stress or cueing response, however the stress responses from LFA sonar is not expected to cause chronic or long-term impacts. For example, as part of determining the potential effects of SURTASS LFA sonar, the Navy conducted the LFS SRP, which exposed baleen whales to received levels ranged from 120 to 155 dB. In response to LFA sonar, blue and fin whales did not exhibit any overt behavioral responses or changes in distribution, whereas gray whales avoided the sound source following exposure and humpback whales lengthened their songs in response to low frequency broadcasts. All responses to the sound source were short-term (Miller et al. 2000a; Clark and Fristrup 2001b; Croll et al. 2001b; Fristrup et al. 2003; Nowacek et al. 2007). When an LFA sonar signal (SLs of 170 and 178 dB re: 1 µPa (rms)) was placed in the

center of gray whale migration corridor, the animals made minor course changes and resumed their normal activities within tens of minutes after the initial exposure to the LFA sonar signal (Clark and Fristrup 2001b). When the source was moved offshore to the edge of the migratory corridor, with an increased SL to maintain the same received levels at the whales, the migrating animals exhibited no response to the sonar (Clark et al. 1999; Navy 2017b; Navy 2018b). Miller et al. (2000b) and Fristrup et al. (2003) found that humpback whales might lengthen their songs in response to low frequency broadcasts, but this response was relatively brief in duration, with the animals resuming normal behaviors within a couple hours of the last LFA sonar source transmission. These temporary responses are not expected to impact the fitness of any individual animals as the responses are not likely to adversely affect the ability of the animals to forage, detect predators, select a mate, or reproduce successfully. For example, Fristrup et al. (2003) stated in regards to the response of humpback whales to low-frequency sound broadcasts that "dramatic changes in humpback singing behavior would have demographic consequences, but the effects documented here do not seem to pose this risk." Further, as noted in (Southall et al. 2007b; Southall et al. 2019a), substantive behavioral reactions to noise exposure (such as disruption of critical life functions, displacement, or avoidance of important habitat) are considered more likely to be significant if they last more than 24 hours, or recur on subsequent days. This is not expected to occur as a result of SURTASS LFA sonar. This conclusion is further supported by Navy monitoring of Navy-wide activities since 2006 which has documented hundreds of thousands of marine mammals on training and testing range complexes and there are only two instances of overt behavioral change that have been observed and there have been no demonstrable instances of injury to marine mammals as a result of non-impulsive acoustic sources such as low frequency active sonar. Because we do not expect any fitness consequences from any individual animals to result from instances of behavioral response, we do not expect any population (stock or DPS) level effects from these behavioral responses.

As described further in Section 8.2.7, establishing a causal link between anthropogenic noise, animal communication, and individual impacts as well as population viability is difficult to quantify and assess (McGregor 2013; Read et al. 2014a; Southall et al. 2016b; Southall et al. 2019a). To date, "we do not yet have the data to underpin the link between behavioral response and population consequences" (Harris et al. 2017a). It is difficult to assess the effects of sounds individually and cumulatively on marine species because a number of factors can influence these effects including: indirect effects, age class, prior experience, behavioral state at the time of exposure, and that responses may be influenced by other non-sound related factors (Kight and Swaddle 2011; Ellison et al. 2012b; Goldbogen et al. 2013b; McGregor 2013; Read et al. 2014b; Williams et al. 2014; Friedlaender et al. 2016; DeRuiter et al. 2017; Harris et al. 2017a). However, although there is significant uncertainty, based upon the available evidence and the foregoing analysis, we conclude that modeled instances of behavioral disturbance and TTS are unlikely to cause aggregate or long-term adverse effects on the baleen whales considered in this consultation, such as abandonment of important habitat or adverse physiological effects resulting from chronic or long-term stress.

8.6.1.2 *Odontocetes*

As discussed previously, based on the performance of the SURTASS LFA sonar system and the mitigation measures the Navy has used with the sonar system over more than 17 years of its use (2002 through 2019), it is unlikely that any odontocetes (e.g., sperm and Main Hawaiian Islands Insular DPS of false killer whales) would be exposed to received levels equal to or greater than 180 dB re: 1 µPa (rms) (or even 175 dB re: 1 µPa (rms) considering the buffer zone that will be implemented). The available evidence suggests that at received levels below 180 dB, exposure to SURTASS LFA sonar transmissions is not likely to result in injury, TTS, significant masking, stranding, resonance effects, or long-term behavioral effects in odontocetes. Though data are limited that consider the behavioral response of odontocetes to low-frequency sources, the best scientific and commercial data available (presented in sections 8.2) suggest that exposing individual odontocetes to SURTASS LFA sonar may cause those animals to react behaviorally, but many animals exposed at these received levels may not respond at all. Below we discuss the likely responses of odontocetes to exposures that could result in behavioral response and the potential for these exposures to result in fitness consequences to individual animals.

It is worth noting here that SURTASS LFA sonar operates at a frequency between 100 and 500 Hz, which is at the lower end of odontocete's hearing range (150 Hz to 160 kHz) (NMFS 2018a). Aicken et al. (2005) monitored the behavioral responses of sperm whales to an LFA sonar system that was being developed for use by the British Navy and found no evidence of behavioral responses that could be attributed to the LFA sonar. On the other hand and as described further in section 8.2, Antunes et al. (2014) and Miller et al. (2014) did observe avoidance responses from odontocetes at received levels ranging from 142±15 dB re: 1 µPa to approximately 170 dB re: 1 µPa (rms) or 173 dB cSEL. In the Antunes et al. (2014) study, the responses did not last longer than the duration of the sonar exposure and the animals returned to previous movement patterns once the sonar ceased transmitting. Isojunno et al. (2016b) found that sperm whales reduced foraging effort during exposure to 1 to 2 kHz sonar (a higher frequency than SURTASS LFA sonar), but that the animals transitioned back to foraging within approximately eight minutes following cessation of the exposure. Responses to LFA sonar (1 to 2 kHz) were very similar to responses to killer whale playbacks, indicating the potential of LFAS to have similar disturbance effects as an increasing predation risk (Cure et al. 2016). All changes in foraging activities included alteration or cessation of the production of foraging sounds (i.e. regular clicks and buzzes) and changes in the dive profile (Cure et al. 2016). Changes in coda and slow click production rates were also observed in many exposure sessions (Cure et al. 2016). In addition it was noted that sperm whales responded more strongly and at lower sound levels to low frequency active sonar (LFA sonar; 1−2 kHz) than mid-frequency active sonar (MFAS; 6−7 kHz), however it should be taken into account that LFA sonar signals were both transmitted and received at higher sound pressure levels (maximum received sound pressure level of 170 dB re 1 µPa (rms)) than MFAS (maximum received sound pressure level of 158 dB re 1 µPa (rms)) (Cure et al. 2016).

As noted above, to preserve the saliency of their vocalizations and the coherence of their social interactions, odontocetes might have to make one or more vocal adjustments. Because any reductions in the active space of whale vocalizations that result from SURTASS LFA sonar would be temporary and episodic, any vocal adjustments odontocetes would have to make would also be temporary and not have substantial energetic costs. Studies on a captive false killer whale have demonstrated an ability to proactively change hearing sensitivity, apparently for protection, when a warning sound was provided prior to a more intense sound and that the animal learned to change its hearing sensitivity when warned that a loud sound was about to arrive (Nachtigall and Supin 2013). Controlled exposure experiments in the Bahamas found that after each MFA reception of simulated MFA sonar sounds (3.1 to 3.4 kHz, SL 160 to 211 dB re: 1 µPa (rms)) false killer whales increased their whistle rate and produced whistles that were more similar in their frequency characteristics to MFA sonar (Goldbogen et al. 2013b). If necessary, we would expect odontocetes to be able to similarly alter their communication in response to LFA sonar.

Similar to the behavioral reactions of mysticetes, potential behavioral responses of odontocetes to SURTASS LFA sonar are not expected to impact the fitness of any individual animals as the responses are not likely to adversely affect the ability of the animals to forage, detect predators, select a mate, or reproduce successfully. As stated previously, all behavioral reactions are assumed to occur due to a preceding stress or cueing response, however the stress responses from LFA sonar is not expected to cause chronic or long-term impacts. As noted in (Southall et al. 2007b; Southall et al. 2019a), substantive behavioral reactions to noise exposure (such as disruption of critical life functions, displacement, or avoidance of important habitat) are considered more likely to be significant if they last more than 24 hours, or recur on subsequent days. As noted from the studies mentioned above, behavioral reactions are not expected to last more than 24 hours or recur on subsequent days such that an animal's fitness could be impacted(e.g., Antunes et al. 2014; Isojunno et al. 2016b). Because we do not expect any fitness consequences from any individual animals to result from instances of behavioral response, we do not expect any population (stock or DPS) level effects from these behavioral responses.

Establishing a causal link between anthropogenic noise, animal communication, and individual impacts as well as population viability is difficult to quantify and assess (McGregor 2013; Read et al. 2014a; Southall et al. 2016b; Southall et al. 2019a). To date, "we do not yet have the data to underpin the link between behavioral response and population consequences" (Harris et al. 2017a). It is difficult to assess the effects of sounds individually and cumulatively on marine species because a number of factors can influence these effects including: indirect effects, age class, prior experience, behavioral state at the time of exposure, and that responses may be influenced by other non-sound related factors (Kight and Swaddle 2011; Ellison et al. 2012b; Goldbogen et al. 2013b; McGregor 2013; Read et al. 2014b; Williams et al. 2014; Friedlaender et al. 2016; DeRuiter et al. 2017; Harris et al. 2017a). For example, as discussed previously, New et al. (2013) developed a mathematical model simulating a functional link between feeding energetics and a species' requirements for survival and reproductions for 21 species of beaked whale (not ESA-listed, but also odontocetes). However, while the New et al. (2013) model

provides a test case for future research, this pilot study has very little of the critical data necessary to form any conclusions applicable to current management decisions. The authors note the need for more data on prey species and reproductive parameters including gestation and lactation duration, as the model results are particularly affected by these assumptions. Therefore, any suggestion of biological sensitivity to the simulation's input parameters is uncertain.

Although there is uncertainty, based upon the available evidence and the foregoing analysis, we conclude that modeled instances of behavioral disturbance is unlikely to cause aggregate or long-term adverse effects on the odontocetes considered in this opinion, such as abandonment of important habitat or adverse physiological effects resulting from chronic or long-term stress.

8.6.1.3 *Pinnipeds*

As discussed previously, based on the performance of the SURTASS LFA sonar system and the mitigation measures the Navy has used with the LFA sonar system over more than 17 years (2002 through 2019) of sonar deployment, it is unlikely that any ESA-listed pinnipeds (Hawaiian monk seals, Southern DPS of spotted seals, or Western DPS of Steller sea lions) would be exposed to received levels equal to or greater than 180 dB re 1 μPa (rms) (or even 175 dB re 1 μPa (rms) considering the buffer zone that will be implemented). The available evidence suggests that at received levels below 180 dB, exposure to LFA sonar transmissions are not likely to result in injury (including PTS), masking, stranding, resonance effects, or other long-term behavioral effects in pinnipeds. The best scientific and commercial data available (presented in section 8.2) suggest that exposing individual pinnipeds to SURTASS LFA sonar may cause those animals to react behaviorally or experience TTS. Below we discuss the likely responses of pinnipeds to exposures that could result in TTS or behavioral response and the potential for these exposures to result in fitness consequences to individual animals.

Limited information is available on the effect of low-frequency sonar on pinnipeds. For this reason, we rely largely on data from non-listed pinniped species and other marine mammals (i.e., cetaceans) in our assessment of the likely responses of ESA-listed pinnipeds to SURTASS LFA sonar. We also rely on information regarding how pinnipeds respond to other sources of anthropogenic noise. Pinnipeds can hear in the frequency range from 50 Hz up to 86 kHz (NMFS 2018a). Since SURTASS LFA sonar operates at a frequency between 100 and 500 Hz, we would expect pinnipeds to detect SURTASS LFA sonar if exposed.

Similar to other marine mammal species, behavioral responses of pinnipeds can range from a mild orienting response, or a shifting of attention, to flight and panic. As stated previously, all behavioral reactions are assumed to occur due to a preceding stress or cueing response, however the stress responses from LFA sonar is not expected to cause chronic or long-term impacts. For example, different responses displayed by captive and wild phocid seals to sound judged to be 'unpleasant' have been reported; where captive seals habituated (did not avoid the sound), and wild seals showed only avoidance behavior. Captive seals received food (reinforcement) during sound playback, while wild seals were exposed opportunistically. These results indicate that motivational state (e.g., reinforcement via food acquisition) can be a factor in whether or not an

animal habituates to novel or unpleasant sounds. Captive studies with other pinnipeds have shown a reduction in dive times when presented with qualitatively 'unpleasant' sounds. These studies indicated that the subjective interpretation of the pleasantness of a sound, minus the more commonly studied factors of received sound level and sounds associated with biological significance, can affect diving behavior (Götz and Janik 2011). More recently, a controlled-exposure study was conducted with Navy California sea lions at the Navy Marine Mammal Program facility specifically to study behavioral reactions (Houser et al. 2013). Animals were trained to swim across a pen, touch a panel, and return to the starting location. During transit, a simulated mid-frequency sonar signal was played. Behavioral reactions included increased respiration rates, prolonged submergence, and refusal to participate, among others. Younger animals were more likely to respond than older animals, while some sea lions did not respond consistently at any level.

Kvadsheim et al. (2010) found that captive hooded seals (*Cystophora cristata*) reacted to 1 to 7 kHz sonar signals by moving to the areas of least sound pressure level, at levels between 160 and 170 dB re: 1 µPa. Finneran et al. (2003) found that trained captive sea lions showed avoidance behavior in response to impulsive sounds at levels above 165 to 170 dB (rms). These studies are in contrast to the results of Costa et al (2003) which found that free-ranging elephant seals showed no change in diving behavior when exposed to very low frequency sounds (55 to 95 Hz) at levels up to 137 dB (though the received levels in this study were much lower) (Costa et al. 2003). Similar to behavioral responses of mysticetes and odontocetes, potential behavioral responses of pinnipeds to SURTASS LFA sonar are not expected to impact the fitness of any individual animals as the responses are not likely to adversely affect the ability of the animals to forage, detect predators, select a mate, or reproduce successfully. As noted in (Southall et al. 2007b; Southall et al. 2019a), substantive behavioral reactions to noise exposure (such as disruption of critical life functions, displacement, or avoidance of important habitat) are considered more likely to be significant if they last more than 24 hours, or recur on subsequent days. Behavioral reactions are not expected to last more than 24 hours or recur on subsequent days such that an animal's fitness could be impacted as shown in (Götz and Janik 2011).

Establishing a causal link between anthropogenic noise, animal communication, and individual impacts as well is difficult to quantify and assess (McGregor 2013; Read et al. 2014a; Southall et al. 2016b; Southall et al. 2019a). To date, "we do not yet have the data to underpin the link between behavioral response and population consequences" (Harris et al. 2017a). It is difficult to assess the effects of sounds individually and cumulatively on marine species because a number of factors can influence these effects including: indirect effects, age class, prior experience, physical condition and behavioral state at the time of exposure, and that responses may be influenced by other non-sound related factors (Kight and Swaddle 2011; Ellison et al. 2012b; Goldbogen et al. 2013b; McGregor 2013; Read et al. 2014b; Williams et al. 2014; Friedlaender et al. 2016; DeRuiter et al. 2017; Harris et al. 2017a).

Although there is significant uncertainty, based upon the available evidence and the foregoing analysis, we conclude that instances of behavioral disturbance are unlikely to cause aggregate or long-term adverse effects on the pinnipeds considered in this opinion, such as abandonment of important habitat or adverse physiological effects resulting from chronic or long-term stress.

8.6.2 Sea Turtles

Little is known about how sea turtles (green, hawksbill, olive ridley, leatherback, and loggerhead) use sound in their environment. Based on knowledge of their sensory biology (Moein Bartol and Musick 2003; Bartol and Ketten 2006), sea turtles may be able to detect objects within the water column (e.g., vessels, prey, predators) via some combination of auditory and visual cues. However, while sea turtles may rely on acoustic cues to identify nesting beaches, they appear to rely on other non-acoustic cues for navigation, such as magnetic fields (Lohmann and Lohmann 1996b; Lohmann and Lohmann 1996a) and light (Avens and Lohmann 2003). Additionally, they are not known to produce sounds underwater for communication.

Although the information on the hearing capabilities of sea turtles is limited, the information available suggests that the auditory capabilities of sea turtles are centered in the low-frequency range (less than 2 kHz) (Ridgway et al. 1969; Lenhardt et al. 1983; O'Hara and Wilcox 1990; Lenhardt et al. 1994; Bartol et al. 1999a; Martin et al. 2012; Piniak et al. 2012), with greatest sensitivity below one kHz. A more recent review on sea turtle hearing and sound exposure indicated that sea turtles detect sounds at less than 1,000 Hz (Popper et al. 2014).

No data are available indicating the potential response of sea turtles to sonar (Popper et al. 2014). McCauley et al. (2000b) studied the response of green and loggerhead sea turtles to airgun arrays at two km and at one km with received levels of 166 and 175 dB re: 1 µPa, respectively. They reported that the sea turtles responded consistently above received levels of about 166 dB re: 1 µPa by increasing their swimming activity compared to period during which the airgun was not operating. Above 175 dB re: 1 µPa their behavior became erratic and might have indicated an agitated state.

O’Hara and Wilcox (1990) exposed loggerhead turtles to low-frequency sound from two types of seismic airguns with SLs approximating 256 and 262 dB re: 1 µPa (the paper does not state whether this was peak, peak-to-peak, or rms). With airguns firing at a rate of four times per minute and SLs of 256 dB, the distribution of loggerhead turtles was not significantly different than during control trials. When they increased the SLs to about 262 dB, the sea turtles avoided the seismic airgun when it fired at four or eight times per minute. Although the sound source in this experiment is not directly comparable to the LFA sonar associated with the proposed training and testing activities of the SURTASS LFA sonar system, the results of this study illustrate the relative insensitivity of sea turtles (at least loggerhead turtles) to low-frequency sound.

In their *Sound Exposure Guidelines for Sea Turtles and Fishes*, a technical report developed and approved by Accredited Standards Committee S3/SC 1 Animal Bioacoustics, Popper et al.

(2014) determined that the relative risk of sea turtles responding behaviorally to low-frequency sonar is low, regardless of the distance from the source. Because of this, we do not expect sea turtles would exhibit long-term behavioral responses that could impact an individual's fitness if they are exposed to SURTASS LFA sonar. Popper et al. (2014) also concluded that the risk of sea turtles experiencing immediate morality, serious injury that could lead to death, or recoverable injury was low from exposure to low-frequency sonar. Further, if the animal was located far from the sound source, there was a low risk it could experience TTS, and a moderate risk if the animal was located intermediate or close distances to the source. Due to the monitoring and mitigation measures implemented during SURTASS LFA sonar transmissions that would reduce the likelihood of sea turtles being in close proximity to the sound source, and because a sea turtle would need to remain within 44 m (143 ft) of the LFA sonar for an entire 60-seconds signal without being detected to experience auditory effects (see Section 8.3 for additional detail), any exposure of sea turtles to LFA sonar signals is not expected to result in morality, injury, or TTS.

Based on the limited evidence available, sea turtles exposed to LFA sonar may hear the sound. At levels below 175 dB re: 1 µPa, they may not react at all or they may increase their swimming speed. Any changes in their swimming behavior would not be expected to result in a measurable threat to individual sea turtles.

8.7 Risk Analysis

8.7.1 Marine Mammals

In the exposure and response analysis, we established that a range of impacts including TTS, behavioral response, and stress are likely to occur due to exposure to Navy SURTASS LFA sonar training and testing events. In this section we assess the likely consequences of the responses to the individuals that have been exposed. (We determined that the potential effects of masking from sonar are limited because the percentage of the total anthropogenic acoustic energy budget added by each LFA sonar source is estimated to be 0.21 percent per system (or less), when the other man-made sources are considered (Hildebrand 2005a). In addition, the duty cycles of most military sonars and the transient nature of sonar use, so we have concluded that there is little to no risk associated with exposure and response to masking. As such, the potential effects of masking will not be discussed further in this section.) In order to consider the potential consequences of temporary hearing impacts, behavioral response, and stress to affected animals, we must also consider the context of the exposure and response scenario including the following: 1) the duration of the exposure and associated response, 2) whether or not repeated exposures would be expected, 3) the behavioral state of the animal at the time of the response, and 4) the health of the animal at the time of the response.

Since marine mammals depend on acoustic cues for vital biological functions (e.g., orientation, communication, finding prey, avoiding predators), fitness consequences could occur to individual animals from hearing threshold shifts that last for a long time, occur at a frequency utilized by the animal for acoustic cues, and are of a profound magnitude. A hearing threshold

shift of limited duration, occurring in a frequency range that does not coincide with that used for vocalization or recognition of important acoustic cues, would likely have no effect on an animal's fitness. Based on the literature cited in Section 8.2 and the response analysis, we expect instances of TTS from Navy sonar on low-frequency cetaceans to be short-term and of relatively low severity because of animal avoidance and the transient nature of most Navy sonar sources.

The literature described in the response analysis and in Section 8.2.3 indicate that most behavioral responses that have been observed to low-frequency sonar exposure are of mild to moderate severity, often only lasting for the duration of the exposure.

The duration and magnitude of the proposed activity is important to consider in determining the likely severity, duration, and potential consequences of exposure and associated response to Navy sonar. As noted in Southall et al. (2007a), substantive behavioral reactions to noise exposure (such as disruption of critical life functions, displacement, or avoidance of important habitat) are considered more likely to be significant if they last more than 24 hours, or recur on subsequent days. As discussed earlier, only a maximum of 496 total transmission hours of SURTASS LFA sonar will occur for the first four years of activities and 592 transmission hours during the last three years. In addition, transmission of LFA will be spread out over multiple mission areas in a large open-ocean action area (See Figure 2).

When considering the potential consequences of exposure and response to Navy sonar, we must also take into account the health of the individual animal affected. Individuals that are in good health, with sufficient energy reserves, are likely to be much more resilient when faced with long-term or repeated disturbance than an animal in poor condition. As described in Harris et al. (2017b), one approach to understanding the potential importance of a behavioral response is to consider an animal's energy budget. Marine mammal behavioral research has indicated that many species including humpback whales (Silve et al. 2016), blue whales (Goldbogen et al. 2013a), and sperm whales (Isojunno et al. 2016a) may disrupt foraging when exposed to anthropogenic noise. If the animals are not able to make up for lost foraging opportunities due to such exposure, this could have consequences on the affected animal's available energy supply. For individuals in good health, with sufficient energy reserves, such a reduction could likely be compensated for at a later time, provided the animal is not subject to sustained disruption. However, for individuals in a compromised state, a reduction in available energy has a higher likelihood of being consequential, depending on the duration of the disruption (i.e., long duration disruptions would have a higher likelihood of being consequential).

Quantifying the fitness consequences of sub-lethal impacts is exceedingly difficult for marine mammals because of the limitations of studying these species (e.g., due to the costs and logistical challenges of studying animals that spend the majority of time underwater). Harris et al. (2017b) summarized the research efforts conducted to date that have attempted to understand the ways in which behavioral responses may result in long-term consequences to individuals and populations. Efforts have been made to try and quantify the potential consequences of such responses, and frameworks have been developed for this assessment (e.g., PCoD). However,

models that have been developed to date to address this question require many input parameters and, for most species, there are insufficient data for parameterization (Harris et al. 2017b). A key factor limitation in these models is that we often do not have empirical data to link sub-lethal behavioral responses to effects on animal vital rates.

Behavioral responses may impact health through a variety of different mechanisms, but most (PCoD) models focus on how such responses affect an animal's energy budget (New et al. 2014; King et al. 2015; Costa et al. 2016; NAS 2017; Villegas-Amtmann et al. 2017; Farmer et al. 2018). Responses that relate to foraging behavior, such as those that may indicate reduced foraging efficiency (Miller et al. 2009) or involve the complete cessation of foraging, may result in an energetic loss to animals. Other behavioral responses, such as avoidance, may have energetic costs associated with traveling (NAS 2017). Important in considering whether or not energetic losses, whether due to reduced foraging or increased traveling, will affect an individual's fitness is considering the duration of exposure and associated response. Nearly all studies and experts agree that infrequent exposures of a single day or less are unlikely to impact an individual's overall energy budget and that long duration and repetitive disruptions would be necessary to result in consequential impacts on an animal (Southall et al. 2007c; New et al. 2014; King et al. 2015; Villegas-Amtmann et al. 2015; Harris et al. 2017c; NAS 2017; Farmer et al. 2018).

We also recognize that aside from affecting health via an energetic cost, a behavioral response could result in more direct impacts to health and/or fitness. For example, if a marine mammal hears Navy LFA sonar and avoids the area, this may cause it to travel to an area with other threats such as vessel traffic or fishing gear. However, we find such possibilities (i.e., that a behavioral response would lead directly to a ship strike) to be extremely unlikely and not reasonably certain to occur, and so focus our risk analysis on the energetic costs associated with a behavioral response.

To summarize, we would expect many exposures and potential responses of ESA-listed marine mammals to LFA sonar. Based on the controlled exposure experiments and opportunistic research presented above, responses are expected to be short term, with the animal returning to normal behavior patterns shortly after the exposure is over. However, there is some uncertainty due to the limitations of the controlled exposure experiments and observational studies used to inform our analysis (i.e. lacking data on effects specific to LFA sonar compared to other forms of sonar (i.e. MFA sonar)) . Additionally, Southall et al. (2016a) suggested that even minor, sub-lethal behavioral changes may still have significant energetic and physiological consequences given sustained or repeated exposure. Quantifying the fitness consequences of sub-lethal impacts from acoustic stressors is exceedingly difficult for marine mammals and we do not currently have data to conduct a quantitative analysis on the likely consequences of such sub-lethal impacts. While we are unable to conduct a quantitative analysis on how sub-lethal behavioral effects and temporary hearing impacts may impact animal vital rates (and therefore fitness), based on the best available information, we expect an increased likelihood of consequential

effects when exposures and associated effects are long-term and repeated, occur in locations where the animals are conducting critical activities, and when the animal affected is in a compromised state.

During exposure, affected animals may be engaged in any number of activities including, but not limited to, migration, foraging, or resting. If marine mammals exhibited a behavioral response to Navy sonar, these activities would be disrupted and it may pose some energetic cost. However, as noted previously, responses to Navy sonar are anticipated to be short term and instances of hearing impairment are expected to be mild or moderate. Based on best available information that indicates marine mammals resume normal behavior quickly after the cessation of sound exposure (e.g., Melcon et al. 2012; Goldbogen et al. 2013a), we anticipate that exposed animals will be able to return normal behavioral patterns after this short duration activity ceases. Goldbogen et al. (2013a) suggested that if the documented temporary behavioral responses interrupted feeding behavior, this could have impacts on individual fitness and eventually population health. However, for this to be true, we would have to assume that an individual animal could not compensate for this lost feeding opportunity by either immediately feeding at another location, by feeding shortly after cessation of acoustic exposure, or by feeding at a later time. There is no indication this is the case, particularly since unconsumed prey would still be available in the environment following the cessation of acoustic exposure (i.e., sonar could cause scattering of prey, but would not be expected to injure or kill it). There would likely be an energetic cost associated with any temporary habitat displacement to find alternative locations for foraging, but unless disruptions occur over long durations or over subsequent days, we do not anticipate this movement to be consequential to the animal over the long-term (Southall et al. 2007b).

In summary, we determine that the risk of effects from LFA sonar on marine mammals is small. Further, we anticipate that any instances of TTS will be of minimum severity and short duration. This conclusion is based on literature indicating that even following relatively prolonged periods of sound exposure resulting TTS, recovery occurs quickly (Finneran 2015). Additionally, we do not anticipate these species will experience long duration or repeat exposures within a short period of time due to the species' wide ranging life history, the short duration of annual SURTASS LFA sonar activities, and the large geographic action area. This decreases the likelihood that animals and Navy activities will co-occur for extended periods of time or repetitively over the duration of an activity. For these reasons, we do not anticipate that instances of behavioral response or TTS from Navy SURTASS LFA activities will result in fitness consequences to individual ESA-listed marine mammals in the action area.

8.7.2 Sea Turtles

As discussed in the response analysis and in Section 8.3, there is limited data on the effects of low-frequency sound on sea turtles. However, we established that behavioral response is possible, but not considered a high risk that would substantially affect an individual sea turtle's ability to detect important environmental cues, hinder important life functions, or result in TTS.

Although the proximity and context of the exposure would influence the degree of behavioral response a sea turtle sustains, mitigation methods used during SURTASS LFA sonar training and testing activities would likely detect a sea turtle before a more severe behavioral response occurs. Also, as discussed in Section 8.6.2, the 2014 *ANSI Guidelines* state that the risk of a sea turtle responding to low-frequency sonars (less than 1 kHz) is low regardless of proximity to the source (Popper et al. 2014). However, it is possible a turtle could respond to sounds within their limited hearing range and react, especially if they are close to the source. If this were to occur, as with other reactions to sound, sea turtles could exhibit avoidance, changes to swim speed or depth, erratic or minor behaviors.

Although sea turtle use of sound is not well understood, they generally are not thought to rely heavily on sound for many of life functions such as foraging or navigation. Similarly, the significant behavioral disruptions sea turtles may exhibit such as startle responses, temporary disruption in feeding or basking, etc. are not expected to persist. Physiological stress responses are also assumed to occur concurrent with any of these behavioral responses but would also return to normal after sonar sound exposure ceases. As described above, a short, low-level stress response may be adaptive and beneficial for sea turtles in that it may result in sea turtles avoiding the stressor and minimizing their exposure. Given that stress responses are expected to be minor and short-term, we do not anticipate that they would impact the fitness of any individual sea turtle. In addition, some of the adverse effects may be ameliorated further by the mitigation measures the Navy proposes to implement, such as powering down sonar if turtles are observed in the mitigation zone which could reduce the type (intensity and proximity to the source), severity, and duration of exposure. Therefore, we do not expect individual sea turtles that experience behavioral responses and physiological stress or temporary masking from sonar to sustain fitness consequences, and do not expect population level effects that preclude conservation and recovery of sea turtle species.

9 CUMULATIVE EFFECTS

"Cumulative effects" are those effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 CFR §402.02). Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

During this consultation, NMFS searched for information on future state, tribal, local, or private actions that were reasonably certain to occur in the action area. Operation of SURTASS LFA sonar is restricted to sound levels less than 180 dB within the territorial waters of the United States, indicating that the vast majority of the action area is outside the territorial waters of the United States of America, which would preclude the possibility of future state, tribal, or local action that would not require some form of federal funding or authorization. NMFS conducted electronic searches of Google and other electronic search engines. We are not aware of any state

or private entities that are likely to occur in the action area during the foreseeable future that were not considered in the *Environmental Baseline* section of this opinion.

10 INTEGRATION AND SYNTHESIS

The *Integration and Synthesis* section is the final step in our assessment of the risk posed to species and critical habitat as a result of implementing the proposed action. In this section, we add the *Effects of the Action* (Section 8) to the *Environmental Baseline* (Section 7) and the *Cumulative Effects* (Section 9) to formulate the agency's biological opinion as to whether the proposed action is likely to reduce appreciably the likelihood of both the survival and recovery of an ESA-listed species in the wild by reducing its numbers, reproduction, or distribution. These assessments are made in full consideration of the *Status of the Species Section* (Section 6).

The following discussions separately summarize the probable risks the proposed action poses to threatened and endangered species and critical habitat that are likely to be exposed. These summaries integrate the exposure profiles presented previously with the results of our response analyses for each of the actions considered in this opinion. Where stressors were determined to have insignificant or discountable effects to all species earlier in this opinion, those stressors will not cause adverse effects to individuals of those species or cause a population or species level effect.

10.1 Marine Mammal Species and DPSs Affected by Seven-Year SURTASS LOA

10.1.1 Blue Whale

In determining whether the Navy's SURTASS LFA sonar routine training and testing activities in the action area are likely to jeopardize the survival and recovery of blue whales, we assessed effects of the action against the aggregate effects of everything in the *Environmental Baseline* that has led to the current *Status of Endangered Species Act-Listed Resources* and, those effects of future non-Federal activities that are reasonably certain to occur within the action area in the reasonably foreseeable future.

As described previously in Section 6.1, current estimates indicate there are approximately 5,000 to 12,000 blue whales globally (IWC 2007). Under the LOA that will be issued for the proposed seven-year rule, assuming the Navy reaches the maximum extent of the proposed MMPA authorized take, there will be approximately 763 instances of TTS and behavioral responses that constitute ESA take in the form of harassment from SURTASS LFA sonar training and testing activities for blue whales. The individuals affected by SURTASS LFA sonar training and testing activities would be from populations in the Western North Pacific Ocean, the Central North Pacific Ocean, Hawaii, the North Indian Ocean, and South Indian Ocean. Based on the maximum annual instances of MMPA harassment (TTS and behavioral response) during which takes will be greatest for SURTASS LFA sonar training and testing activities (years 5-7, See Table 9), instances of take would result in 1.14 percent of the Western North Pacific, 2.85 percent of the Central North Pacific – Hawaii, 0 percent of the North Indian, and 0.07 of the South Indian

populations being affected by SURTASS LFA sonar transmissions. The population abundances used for these percentages are presented in Table 4 and their associated references are in Appendix A. However, it is important to note that recent data of the entire Western North Pacific population is lacking as stated in Branch et al. (2016). Based on the Navy's operational history, we assume that these same five populations of blue whale will experience TTS and behavioral responses that constitute take in the form of harassment from SURTASS LFA sonar at levels no higher than those proposed in the Navy's biological evaluation (Navy 2018a).

As described further in section 8.2 and 8.5, the evidence available suggests that when exposed to SURTASS LFA sonar transmissions, blue whales, like other baleen whales, are not likely to be killed or experience PTS injury, significant masking, stranding, resonance effects, or behavioral responses that might reduce the longevity or reproductive success of individuals that have been exposed. Instead, the best scientific and commercial data available suggests that SURTASS LFA sonar transmissions are likely to elicit short-term TTS or behavioral responses that are not likely to persist for long durations to impact the fitness of the individual whales exposed. An action that is not likely to reduce the fitness of individual whales is not likely to reduce the viability of the populations those individual whales comprise of (that is, we would not expect reductions in the reproduction, numbers, or distribution of those populations) and therefore, we do not expect acoustic stressors to result in substantial changes in reproduction, numbers, or distribution of these populations. By the same logic, we do not anticipate any reductions in survival rate or trajectory of recovery of the species as listed pursuant to the ESA that could be readily perceived or estimated.

The 1998 blue whale recovery plan does not outline downlisting or delisting criteria. The recovery plan does list several stressors potentially affecting the status of blue whales in the Pacific and Indian Oceans that are relevant to SURTASS LFA sonar activities including: vessel strike, vessel disturbance, and military training and testing activities (including sonar). At the time the recovery plan was published, the effects of these stressors on blue whales in the Pacific, and Indian Oceans were not well documented, their impact on recovery was not understood, and no attempt was made to prioritize the importance of these stressors on recovery. As described previously, anthropogenic noise associated with SURTASS LFA sonar training and testing activities is not expected to impact the fitness of any individuals of this species. No mortality of blue whales is expected to occur from SURTASS LFA sonar training and testing activities.

Based on the evidence available, including the *Environmental Baseline* and *Cumulative Effects*, stressors resulting from the Navy SURTASS LFA sonar routine training and testing activities that will be conducted in the action area (see section 3.6) on an annual basis for the reasonably foreseeable future (assuming there are no significant changes to the *Status of Endangered Species Act-Listed Resources* or *Environmental Baseline*), would not be expected, directly or indirectly, to appreciably reduce the likelihood of the survival or recovery of blue whales in the wild by reducing the reproduction, numbers, or distribution of that species.

10.1.2 Fin Whale

In determining whether Navy SURTASS LFA sonar routine training and testing activities in the action area are likely to jeopardize the survival and recovery of fin whales, we assessed effects of the action against the aggregate effects of everything in the *Environmental Baseline* that has led to the current *Status of Endangered Species Act-Listed Resources* and, those effects of future non-Federal activities that are reasonably certain to occur within the action area in the reasonably foreseeable future.

As described in the *Status of Endangered Species Act-Listed Resources* and *Environmental Baseline* sections of this opinion, some of the primary anthropogenic threats of the survival and recovery of fin whales have been whaling and ship strikes. The threat of whaling has significantly decreased. The current abundance trend for fin whales rangewide including the action area is not well understood.

Under the LOA that will be issued for the proposed seven-year rule, assuming the Navy reaches the maximum extent of the proposed MMPA authorized take, there will be approximately 20,871 instances of TTS and behavioral responses that constitute ESA take in the form of harassment from SURTASS LFA sonar training and testing activities for fin whales. As previously stated in Section 6.2, current estimates indicate there are approximately 10,000 fin whales in U.S Pacific Ocean waters (Nadeem et al. 2016), however estimates of the entire North Pacific is lacking (Würsig et al. 2018). The individuals affected would be from populations from the Western North Pacific Ocean, Indian Ocean, East China Sea, Hawaii, and South Indian Ocean. Based on the maximum annual instances of MMPA harassment (TTS and behavioral response) during which takes will be greatest for SURTASS LFA sonar training and testing activities (years 5-7, See Table 9), instances of take would result in 2.47 percent of the East China Sea, 2.74 percent of the Hawaii, 0 percent of the Indian, and 0.07 of the South Indian population being affected by SURTASS LFA sonar transmissions per year. In addition, annual (from years 5-7, See Table 9) takes of 37.23 percent of the Western North Pacific population is proposed to be taken under the LOA. The population abundances used for these percentages are presented in Table 4 and their associated references are in Appendix A. However, it is important to note that recent data of the entire Western North Pacific population of fin whales is lacking with only sparse sightings data in the area (De Boer 2000). Based on the Navy's operational history, we assume that all populations affected by SURTASS LFA sonar training and testing activities will experience TTS and behavioral responses that constitute ESA take in the form of harassment from SURTASS LFA sonar at levels no higher than those proposed in the Navy's biological evaluation (Navy 2018a) for the duration of the seven-year proposed action and into the reasonably foreseeable future.

It is important to note that it is unlikely that takes would be exactly evenly distributed across all individuals and it is therefore more reasonable to assume that some number of individuals would be taken more or fewer times than others. Even where one individual may be taken (by MMPA Level B harassment in the form of behavioral disturbance or a small degree of TTS) on multiple

days within a year, given the nature of the activities, there is no reason to expect that these takes would likely to occur on sequential days or that the magnitude of exposure within a year would be likely to result in impacts on reproduction or survival, especially given the implementation of mitigation to reduce the severity of impacts.

As described further in section 8.2 and 8.5, the evidence available suggests that when exposed to SURTASS LFA sonar transmissions, fin whales, like other baleen whales, are not likely to be killed or experience PTS injury, significant masking, stranding, resonance effects, or behavioral responses that might reduce the longevity or reproductive success of individuals that have been exposed. Instead, the best scientific and commercial data available suggests that SURTASS LFA sonar transmissions are likely to elicit short-term TTS and behavioral responses that are not likely to impact the fitness of the individual whales exposed. An action that is not likely to reduce the fitness of individual whales is not likely to reduce the viability of the populations those individual whales comprise (that is, we would not expect reductions in the reproduction, numbers, or distribution of those populations) and therefore, we do not expect exposure to SURTASS LFA sonar to result in substantial changes in reproduction, numbers, or distribution of these populations. By the same logic, we do not anticipate any reductions in survival rate or trajectory of recovery of the species as listed pursuant to the ESA that could be readily perceived or estimated.

The 2010 fin whale recovery plan defines three recovery populations by ocean basin (i.e., North Atlantic, North Pacific, and Southern Hemisphere) and sets criteria for the downlisting and delisting of this species. Both downlisting and delisting requirements include abatement of threats associated with fisheries, climate change, direct harvest, anthropogenic noise, and ship collision. Of these, anthropogenic noise and ship collision are relevant to SURTASS LFA sonar training and testing activities. As discussed previously, anthropogenic noise associated with SURTASS LFA sonar training and testing activities will not impact the fitness of any individuals of this species. Downlisting criteria for fin whales includes the maintenance of at least 250 mature females and 250 mature males in each recovery population, which is already exceeded in the North Pacific. To qualify for downlisting, each recovery population must also have no more than a one percent chance of extinction in 100 years. To qualify for delisting, each recovery population must also have no more than a ten percent chance of becoming endangered in 20 years. To our knowledge, a population viability analysis has not been conducted on fin whale recovery populations.

Based on the evidence available, including the *Environmental Baseline* and *Cumulative Effects*, stressors resulting from the Navy SURTASS LFA sonar training and testing activities that will be conducted in the action area (see section 3.6) on an annual basis for the reasonably foreseeable future (assuming there are no significant changes to the *Status of Endangered Species Act-Listed Resources* or *Environmental Baseline*), would not be expected, directly or indirectly, to appreciably reduce the likelihood of the survival or recovery of fin whales in the wild by reducing the reproduction, numbers, or distribution of that species.

10.1.3 Gray Whale – Western North Pacific Population

In determining whether the Navy's SURTASS LFA sonar routine training and testing activities in the action area are not likely to jeopardize the survival and recovery of the Western North Pacific population of gray whales, we assessed effects of the action against the aggregate effects of everything in the *Environmental Baseline* that has led to the current *Status of Endangered Species Act-Listed Resources* and, those effects of future non-Federal activities that are reasonably certain to occur within the action area in the reasonably foreseeable future.

As described in the *Status of the Endangered Species Act-Listed Resources* and *Environmental Baseline* sections of this opinion, some of the primary anthropogenic threats to the survival and recovery of the Western North Pacific population of gray whales have been whaling and ship strikes. The threat of whaling has significantly decreased. The current abundance trend of the Western North Pacific DPS of gray whales rangewide including the action area is not well understood.

Under the LOA that will be issued for the proposed seven-year rule, assuming the Navy reaches the maximum extent of the proposed MMPA authorized take, there will be approximately three instances of behavioral responses that constitute ESA take in the form of harassment from SURTASS LFA sonar training and testing activities for gray whales. As previously stated in Section 6.2, there are approximately 290 individuals in the Western North Pacific DPS of gray whale (Carretta et al. 2019). Based on the maximum annual instances of harassment (from behavioral response) during which takes will be greatest for SURTASS LFA sonar training and testing activities (years 5-7, See Table 9), instances of take would result in only 0.34 percent of the Western North Pacific DPS being affected by SURTASS LFA sonar transmissions per year. Based on the Navy's operational history, we assume that this population will experience behavioral responses that constitute ESA take in the form of harassment from SURTASS LFA sonar at levels no higher than those proposed in the Navy's biological evaluation (Navy 2018a) for the duration of the seven-year proposed action and into the reasonably foreseeable future.

As described further in Section 8.2 and 8.5, the evidence available suggests that when exposed to SURTASS LFA sonar transmissions, gray whales from the Western North Pacific population, like other baleen whales, are not likely to be killed or experience PTS injury, significant masking, stranding, resonance effects, or behavioral responses that might reduce the longevity or reproductive success of individuals that have been exposed. Instead, the best scientific and commercial data available suggests that SURTASS LFA sonar transmissions are likely to elicit short-term behavioral responses that are not likely to impact the fitness of the individual whales exposed. An action that is not likely to reduce the fitness of individual whales is not likely to reduce the viability of the populations those individual whales comprise (that is, we would not expect reductions in the reproduction, numbers, or distribution of those populations) and therefore, we do not expect acoustic stressors to result in substantial changes in reproduction, numbers, or distribution of these populations. By the same logic, we do not anticipate any reductions in survival rate or trajectory of recovery of the species as listed pursuant to the ESA

that could be readily perceived or estimated. There is currently no recovery plan for the Western North Pacific population of gray whale.

Based on the evidence available, including the *Environmental Baseline* and *Cumulative Effects*, stressors resulting from the Navy SURTASS LFA sonar routine training and testing activities that will be conducted in the action area (see section 3.6) on an annual basis for the reasonably foreseeable future (assuming there are no significant changes to the *Status of Endangered Species Act-Listed Resources* or *Environmental Baseline*), would not be expected, directly or indirectly, to appreciably reduce the likelihood of the survival or recovery of gray whales from the Western North Pacific population in the wild by reducing the reproduction, numbers, or distribution of that species.

10.1.4 Humpback Whale – Western North Pacific Distinct Population Segment

In determining whether the Navy's SURTASS LFA sonar routine training and testing activities in the action area are likely to jeopardize the survival and recovery of Western North Pacific DPS of humpback whales, we assessed effects of the action against the aggregate effects of everything in the *Environmental Baseline* that has led to the current *Status of the Endangered Species Act-Listed Resources* and, those effects of future non-Federal activities that are reasonably certain to occur within the action area in the reasonably foreseeable future.

As described in the *Status of the Endangered Species Act-Listed Resources* and *Environmental Baseline* sections of this opinion, some of the primary anthropogenic threats to the survival and recovery of humpback whales have been whaling, fisheries interactions (including entanglement), and ship strikes. The threat of whaling has significantly decreased.

Under the LOA that will be issued for the proposed seven-year rule, assuming the Navy reaches the maximum extent of the proposed MMPA authorized take, there will be approximately 25,210 instances of TTS and behavioral responses that constitute ESA take in the form of harassment from SURTASS LFA sonar training and testing activities for Western DPS humpback whales. As previously stated in Section 6.6, there are approximately 1,000 individuals in the Western North Pacific DPS of humpback whale (Bettridge et al. 2015). Based on the maximum annual instances of harassment (TTS and behavioral response) during which takes will be greatest for SURTASS LFA sonar training and testing activities (years 5-7, See Table 9), instances of take would result in 321.49% of the Western North Pacific population being affected by SURTASS LFA sonar transmissions per year. Based on the Navy's operational history, we assume that this DPS will experience TTS and behavioral responses that constitute ESA take in the form of harassment from SURTASS LFA sonar at levels no higher than those proposed in the Navy's biological evaluation (Navy 2018a) for the duration of the seven-year proposed action and into the reasonably foreseeable future.

It is worth noting that the percentage for the Western North Pacific stock is notably higher than others, which suggests that some individuals are expected to be taken more than once. It is important to note that it is unlikely that takes would be exactly evenly distributed across all

individuals and it is therefore more reasonable to assume that some number of individuals would be taken more or less frequently than others. Even where one individual may be taken (by MMPA Level B harassment in the form of behavioral disturbance or a small degree of TTS) on multiple days within a year, given the nature of the activities, there is no reason to expect that these takes would likely to occur on sequential days or that the magnitude of exposure within a year would be likely to result in impacts on reproduction or survival, especially given the implementation of mitigation to reduce the severity of impacts.

As described further in section 8.2 and 8.5, the evidence available suggests that when exposed to SURTASS LFA sonar transmissions, Western North Pacific DPS of humpback whales, like other baleen whales, are not likely to be killed or experience PTS injury, significant masking, stranding, resonance effects, or behavioral responses that might reduce the longevity or reproductive success of individuals that have been exposed. Instead, the best scientific and commercial data available suggests that SURTASS LFA sonar transmissions are likely to elicit short-term TTS and behavioral responses that are not likely to impact the fitness of the individual whales exposed. An action that is not likely to reduce the fitness of individual whales is not likely to reduce the viability of the populations those individual whales comprise (that is, we would not expect reductions in the reproduction, numbers, or distribution of those populations) and therefore, we do not expect acoustic stressors to result in substantial changes in reproduction, numbers, or distribution of these populations. By the same logic, we do not anticipate any reductions in survival rate or trajectory of recovery of the species as listed pursuant to the ESA that could be readily perceived or estimated.

The general increase in the number of humpback whales range-wide suggests that the stress regime these whales are exposed to including activities in the action area have not prevented these whales from increasing their numbers. Humpback whales have been exposed to Navy SURTASS LFA sonar training and testing activities in the action area for more than a generation. The 1991 humpback whale recovery plan does not outline specific downlisting and delisting criteria. The recovery plan does list several threats known or suspected of impacting humpback whale recovery including subsistence hunting, commercial fishing stressors, habitat degradation, loss of prey species, ship collision, and acoustic disturbance. Of these, ship collision and acoustic disturbance are relevant to SURTASS LFA sonar training and testing activities. As described previously, anthropogenic noise associated with SURTASS LFA sonar training and testing activities will not impact the fitness of any individuals of this species. No mortality of Western North Pacific DPS of humpback whales is expected to occur from SURTASS LFA sonar training and testing activities.

Based on the evidence available, including the *Environmental Baseline* and *Cumulative Effects*, stressors resulting from the Navy SURTASS LFA sonar training and testing activities that will be conducted in the action area (see section 3.6) on an annual basis for the reasonably foreseeable future (assuming there are no significant changes to the *Status of Endangered Species Act-Listed Resources* or *Environmental Baseline*), would not be expected, directly or

indirectly, to appreciably reduce the likelihood of the survival or recovery of Western North Pacific DPS of humpback whales in the wild by reducing the reproduction, numbers, or distribution of that species.

10.1.5 North Pacific Right Whale

In determining whether the Navy's SURTASS LFA sonar routine training and testing activities in the action area are likely to jeopardize the survival and recovery of North Pacific right whales, we assessed effects of the action against the aggregate effects of everything in the *Environmental Baseline* that has led to the current *Status of Endangered Species Act-Listed Resources* and, those effects of future non-Federal activities that are reasonably certain to occur within the action area in the reasonably foreseeable future.

As described in the *Status of Endangered Species Act-Listed Resources* and *Environmental Baseline* sections of this opinion, some of the primary anthropogenic threats to the survival and recovery of North Pacific right whales have been whaling, fisheries interactions (including entanglement), and ship strikes. The threat of whaling has significantly decreased. The current abundance trend for North Pacific right whales rangewide including the action area is not well understood.

Under the LOA that will be issued for the proposed seven-year rule, assuming the Navy reaches the maximum extent of the proposed MMPA authorized take, there will be approximately 722 TTS and behavioral responses that constitute ESA take in the form of harassment. As previously stated in Section 6.4, the only estimate for the western north Pacific population of north Pacific right whale is 922 individuals (Miyashita and Kato 1998). Based on the maximum annual instances of harassment (TTS and behavioral response) during which takes will be greatest for SURTASS LFA sonar training and testing activities (years 5-7, See Table 9), instances of take would result in 13.15 percent of the Western North Pacific stock being affected by SURTASS LFA sonar transmissions per year. Based on the Navy's operational history, we assume that this population will experience TTS and behavioral responses that constitute ESA take in the form of harassment from SURTASS LFA sonar at levels no higher than those proposed in the Navy's biological evaluation (Navy 2018a) for the duration of the seven-year proposed action and into the reasonably foreseeable future.

As described further in section 8.2 and 8.5, the evidence available suggests that when exposed to SURTASS LFA sonar transmissions, North Pacific right whales, like other baleen whales, are not likely to be killed or experience PTS injury, significant masking, stranding, resonance effects, or behavioral responses that might reduce the longevity or reproductive success of individuals that have been exposed. Instead, the best scientific and commercial data available suggests that SURTASS LFA sonar transmissions are likely to elicit short-term behavioral responses that are not likely to impact the fitness of the individual whales exposed. An action that is not likely to reduce the fitness of individual whales is not likely to reduce the viability of the populations those individual whales comprise (that is, we would not expect reductions in the reproduction, numbers, or distribution of those populations) and therefore, we do not expect

acoustic stressors to result in substantial changes in reproduction, numbers, or distribution of these populations. By the same logic, we do not anticipate any reductions in survival rate or trajectory of recovery of the species as listed pursuant to the ESA that could be readily perceived or estimated.

The 2013 North Pacific right whale recovery plan defines two recovery populations in the North Pacific Ocean (the western and eastern) and sets criteria for the downlisting and delisting of this species. The recovery plan lists several stressors potentially affecting the status of North Pacific right whales that are relevant to SURTASS LFA sonar training and testing activities including vessel disturbance and training and testing activities (including sonar). As discussed previously, anthropogenic noise associated with SURTASS LFA sonar training and testing activities will not impact the fitness of any individuals of this species. Downlisting criteria for North Pacific right whales includes the maintenance of at least 250 mature females and 250 mature males in each recovery population. To quantify for downlisting, each recovery population must also have no more than a one percent chance of extinction in 100 years. To qualify for delisting, each recovery population must also have no more than a ten percent chance of becoming endangered in 25 years. To our knowledge, a population viability analysis has not been conducted on North Pacific right whale recovery populations.

Based on the evidence available, including the *Environmental Baseline* and *Cumulative Effects*, stressors resulting from the Navy SURTASS LFA sonar routine training and testing activities that will be conducted in the action area (see section 3.6) on an annual basis for the reasonably foreseeable future (assuming there are no significant changes to the *Status of Endangered Species Act-Listed Resources* or *Environmental Baseline*), would not be expected, directly or indirectly, to appreciably reduce the likelihood of the survival or recovery of North Pacific right whales in the wild by reducing the reproduction, numbers, or distribution of that species.

10.1.6 Sei Whale

In determining whether the Navy's SURTASS LFA sonar routine training and testing activities in the action area are likely to jeopardize the survival and recovery of sei whales, we assessed effects of the action against the aggregate effects of everything in the *Environmental Baseline* that has led to the current *Status of Endangered Species Act-Listed Resources* and, those effects of future non-Federal activities that are reasonably certain to occur within the action area in the reasonably foreseeable future.

As described in the *Status of Endangered Species Act-Listed Resources* and *Environmental Baseline* sections of this opinion, some of the primary anthropogenic threats to the survival and recovery of sei whales have been whaling and ship strikes. The threat of whaling has been eliminated. The current abundance trend for sei whales rangewide including the action area is not well understood.

Under the LOA that will be issued for the proposed seven-year rule, assuming the Navy reaches the maximum extent of the proposed MMPA authorized take, there will be approximately 25,944

TTS and behavioral responses that constitute ESA take in the form of harassment for sei whales. The individuals affected would be from the North Pacific, Hawaii, Southern Indian Ocean, and Northern Indian Ocean populations of sei whales. As stated in Section 6.5, the North Pacific Ocean population was estimated to be 29,632 (95 percent confidence intervals 18,576 to 47,267) between 2010 and 2012 (IWC 2016a; Thomas et al. 2016). Based on the maximum annual instances of harassment (TTS and behavioral response) during which takes will be greatest for SURTASS LFA sonar training and testing activities (years 5-7, See Table 9), instances of take would result in only 5.70 percent of the Hawaii stock, 0 percent of the Southern Indian Ocean stock, and 0.05 percent of the North Indian Ocean stock being affected by LFA SURTASS sonar transmissions per year. In addition, annual (from years 5-7, See Table 9) takes of 64.57 percent of the Western North Pacific stock is proposed to be taken under the LOA. The population abundances used for these percentages are presented in Table 4 and their associated references are in Appendix A. Based on the Navy's operational history, we assume that this population will experience TTS and behavioral responses that constitute ESA take in the form of harassment from SURTASS LFA sonar at levels no higher than those proposed in the Navy's biological evaluation (Navy 2018a) for the duration of the seven-year proposed action and into the reasonably foreseeable future.

It is important to note that it is unlikely that takes would be exactly evenly distributed across all individuals and it is therefore more reasonable to assume that some number of individuals would be taken more or less frequently than others. Even where one individual may be taken (by Level B harassment in the form of behavioral disturbance or a small degree of TTS) on multiple days within a year, given the nature of the activities, there is no reason to expect that these takes would likely to occur on sequential days or that the magnitude of exposure within a year would be likely to result in impacts on reproduction or survival, especially given the implementation of mitigation to reduce the severity of impacts.

As described further in section 8.2 and 8.5, the evidence available suggests that when exposed to SURTASS LFA sonar transmissions, sei whales, like other baleen whales, are not likely to be killed or experience injury, significant masking, stranding, resonance effects, or behavioral responses that might reduce the longevity or reproductive success of individuals that have been exposed. Instead, the best scientific and commercial data available suggests that SURTASS LFA sonar transmissions are likely to elicit short-term behavioral responses that are not likely to impact the fitness of the individual whales exposed. An action that is not likely to reduce the fitness of individual whales is not likely to reduce the viability of the populations those individual whales comprise (that is, we would not expect reductions in the reproduction, numbers, or distribution of those populations) and therefore, we do not expect acoustic stressors to result in substantial changes in reproduction, numbers, or distribution of these populations. By the same logic, we do not anticipate any reductions in survival rate or trajectory of recovery of the species as listed pursuant to the ESA that could be readily perceived or estimated.

The 2011 sei whale recovery plans defines three recovery populations by ocean basin (the North Atlantic, North Pacific, and Southern Hemisphere) and sets criteria for the downlisting and delisting of this species. Both downlisting and delisting requirements include abatement of threats associated with fisheries, climate change, direct harvest, anthropogenic noise, and ship collision. Of these, anthropogenic noise and ship collision are relevant to SURTASS LFA sonar training and testing activities. As described previously, anthropogenic noise associated with SURTASS LFA sonar training and testing activities will not impact the fitness of any individuals of this species. Downlisting criteria for sei whales includes the maintenance of 1,500 mature, reproductive individuals with at least 250 mature females and 250 mature males in each recovery population, which is already exceeded in the North Pacific. To qualify for downlisting, each recovery population must also have no more than a one percent chance of extinction in 100 years. To qualify for delisting, each recovery population must also have no more than a ten percent chance of becoming endangered in 20 years. To our knowledge, a population viability analysis has not been conducted on sei whale recovery populations.

Based on the evidence available, including the *Environmental Baseline* and *Cumulative Effects*, stressors resulting from the Navy SURTASS LFA sonar routine training and testing activities that will be conducted in the action area (see section 3.6) on an annual basis for the reasonably foreseeable future (assuming there are no significant changes to the *Status of Endangered Species Act-Listed Resources* or *Environmental Baseline*), would not be expected, directly or indirectly, to appreciably reduce the likelihood of the survival or recovery of sei whales in the wild by reducing the reproduction, numbers, or distribution of that species.

10.1.7 Sperm Whale

In determining whether the Navy SURTASS LFA sonar routine training and testing activities in the action area are likely to jeopardize the survival and recovery of sperm whales, we assessed effects of the action against the aggregate effects of everything in the *Environmental Baseline* that has led to the current *Status of Endangered Species Act-Listed Resources* and, those effects of future non-Federal activities that are reasonably certain to occur within the action area in the reasonably foreseeable future.

As described in the *Status of Endangered Species Act-Listed Resources* and *Environmental Baseline* sections of this opinion, some of the primary anthropogenic threats to the survival and recovery of sperm whales have been whaling, entanglement in fishing gear, and ship strikes. The threat of whaling has been significantly decreased. The current abundance trend for sperm whales rangewide including the action area is not well understood.

Under the LOA that will be issued for the proposed seven-year rule, assuming the Navy reaches the maximum extent of the proposed MMPA authorized take, there will be approximately 12,483 instances of behavioral responses that constitute ESA take in the form of harassment from SURTASS LFA sonar training and testing activities for sperm whales. The individuals affected would be from the North Pacific, Hawaii, Southern Indian Ocean, and Northern Indian Ocean populations. As stated in Section 6.8, in the eastern tropical Pacific Ocean, the abundance of

sperm whales was estimated to be 22,700 (95 percent confidence intervals 14,800 to 34,600) in 1993, however abundance data throughout other portions of the action area are lacking. Based on the maximum annual instances of harassment from behavioral responses during which takes will be greatest for SURTASS LFA sonar training and testing activities (years 5-7, See Table 9), instances of take would result in only 2.80 percent of the Hawaii population, 0.10 percent of the Southern Indian Ocean population, 0.20 percent of the North Indian Ocean population and 1.68 percent of the North Pacific population being affected by SURTASS LFA sonar transmissions per year. The population abundances used for these percentages are presented in Table 4 and their associated references are in Appendix A. Based on the Navy's operational history, we assume that this population will experience behavioral responses that constitute ESA take in the form of harassment from SURTASS LFA sonar at levels no higher than those proposed in the Navy's biological evaluation (Navy 2018a) for the duration of the seven-year proposed action and into the reasonably foreseeable future.

As described further in section 8.2 and 8.5, the evidence available suggests that sperm whales, like other toothed whales, are not very sensitive to low-frequency sounds. Although sperm whales reduced foraging effort during exposure to 1 to 2 kHz sonar (a higher frequency than SURTASS LFA sonar), it was noted that the animals transitioned back to foraging within approximately eight minutes following cessation of the exposure. Despite the limited number of studies, the available evidence suggests that the risk of injury, significant masking, stranding, resonance effects, or behavioral effects in these whales is very low. The best scientific and commercial data available suggests that SURTASS LFA sonar transmissions are likely to elicit short-term behavioral responses that are not likely to impact the fitness of the individual whales exposed. An action that is not likely to reduce the fitness of individual whales is not likely to reduce the viability of the populations those individual whales comprise (that is, we would not expect reductions in the reproduction, numbers, or distribution of those populations) and therefore, we do not expect acoustic stressors to result in substantial changes in reproduction, numbers, or distribution of these populations. By the same logic, we do not anticipate any reductions in survival rate or trajectory of recovery of the species as listed pursuant to the ESA that could be readily perceived or estimated.

The 2010 sperm whale recovery plan defines three recovery populations by ocean basin (the Atlantic Ocean/Mediterranean Sea, Pacific Ocean, and Indian Ocean) and sets criteria for the downlisting and delisting of this species. Both downlisting and delisting requirements include abatement of threats associated with fisheries, climate change, and direct harvest, oil spills, anthropogenic noise, and ship collision. Of these, anthropogenic noise and ship collision are relevant to SURTASS LFA sonar training and testing activities. As discussed previously, anthropogenic noise associated with SURTASS LFA sonar training and testing activities will not impact the fitness of any individuals of this species. Downlisting criteria for sperm whales includes the maintenance of 1,500 mature, reproductive individuals with at least 250 mature females and 250 mature males in each recovery population, which is already exceeded in the Atlantic Ocean, Indian Ocean, and Pacific Ocean. To qualify for downlisting, each recovery

population must also have no more than one percent chance of extinction in 100 years. To qualify for delisting, each recovery population must also have no more than a ten percent chance of becoming endangered in 20 years. To our knowledge, a population viability analysis has not been conducted on sperm whale recovery populations.

Based on the evidence available, including the *Environmental Baseline* and *Cumulative Effects*, stressors resulting from the Navy SURTASS LFA sonar training and testing activities that will be conducted in the action area (see section 3.6) on an annual basis for the reasonably foreseeable future (assuming there are no significant changes to the *Status of Endangered Species Act-Listed Resources* or *Environmental Baseline*), would not be expected, directly or indirectly, to appreciably reduce the likelihood of the survival or recovery of sperm whales in the wild by reducing the reproduction, numbers, or distribution of that species.

10.1.8 False Killer Whale – Main Hawaiian Islands Insular Distinct Population Segment

In determining whether Navy SURTASS LFA sonar routine training and testing activities in the action area are likely to jeopardize the survival and recovery of the Main Hawaiian Islands Insular DPS of false killer whales, we assessed effects of the action against the aggregate effects of everything in the *Environmental Baseline* that has led to the current *Status of Endangered Species Act-Listed Resources* and, those effects of future non-Federal activities that are reasonably certain to occur within the action area in the reasonably foreseeable future.

As described in the *Status of Endangered Species Act-Listed Resources* and *Environmental Baseline* sections in this opinion, several threats have been identified that may have or continue to lead to the decline of Main Hawaiian Islands Insular DPS false killer whales. These include incidental interactions with commercial and recreational fisheries and aquaculture facilities, prey availability, vessel traffic, anthropogenic noise, small population effects, disease and predation, parasitism, environmental contaminants, harmful algal blooms, and ocean acidification, and climate change (Oleson et al. 2010a). Also, reduced genetic diversity may be a natural, but partially anthropogenically induced factor leading to Main Hawaiian Islands Insular DPS of false killer whale decline (Wearmouth and Sims 2008). The current abundance trend for Main Hawaiian Islands Insular DPS of false killer whales in the action area is not well understood. Some data indicate a slight increase.

Under the LOA that will be issued for the proposed seven-year rule, assuming the Navy reaches the maximum extent of the proposed MMPA authorized take, there will be approximately seven instances of behavioral responses that constitute ESA take in the form of harassment from SURTASS LFA sonar training and testing activities for the Main Hawaiian Islands Insular DPS of false killer whale. As stated in Section 6.7, the most recent stock assessment report abundance estimates for the Main Hawaiian Islands Insular DPS of false killer whale is 167 (CV=0.14) (Carretta et al. 2019). Based on the maximum annual instances of harassment (from behavioral response) during which takes will be greatest for SURTASS LFA sonar training and testing activities (years 5-7, See Table 9), instances of take would result in only 0.49 percent of the stock being affected by SURTASS LFA sonar transmissions per year. Based on the Navy's operational

history, we assume that this DPS will experience behavioral responses that constitute ESA take in the form of harassment from SURTASS LFA sonar at levels no higher than those proposed in the Navy's biological evaluation (Navy 2018a) for the duration of the seven-year proposed action and into the reasonably foreseeable future.

As described further in section 8.2 and 8.5, the evidence available suggests that Main Hawaiian Islands Insular DPS false killer whales, like other toothed whales, are not very sensitive to low-frequency sounds. Despite the limited number of studies, the available evidence suggests that the risk of injury, significant masking, stranding, resonance effects, or behavioral effects in these whales is very low. The best scientific and commercial data available suggests that SURTASS LFA sonar transmissions are likely to elicit short-term behavioral responses that are not likely to impact the fitness of the individual whales exposed. An action that is not likely to reduce the fitness of individual whales is not likely to reduce the viability of the populations those individual whales comprise (that is, we would not expect reductions in the reproduction, numbers, or distribution of those populations) and therefore, we do not expect acoustic stressors to result in substantial changes in reproduction, numbers, or distribution of these populations. By the same logic, we do not anticipate any reductions in survival rate or trajectory of recovery of the species as listed pursuant to the ESA that could be readily perceived or estimated.

Based on the evidence available, including the *Environmental Baseline* and *Cumulative Effects*, stressors resulting from the Navy SURTASS LFA sonar training and testing activities that will be conducted in the action area (see section 3.6) on an annual basis for the reasonably foreseeable future (assuming there are no significant changes to the *Status of Endangered Species Act-Listed Resources* or *Environmental Baseline*), would not be expected, directly or indirectly, to appreciably reduce the likelihood of the survival and recovery of Main Hawaiian Islands Insular DPS of false killer whales in the wild by reducing the reproduction, numbers, or distribution of that species.

10.1.9 Hawaiian Monk Seal

In determining whether the Navy SURTASS LFA sonar routine training and testing activities in the action area are likely to jeopardize the survival and recovery of the Hawaiian monk seal, we assessed effects of the action against the aggregate effects of everything in the *Environmental Baseline* that has led to the current *Status of Endangered Species Act-Listed Resources* and, those effects of future non-Federal activities that are reasonably certain to occur within the action area in the reasonably foreseeable future.

As described in the *Status of Endangered Species Act-Listed Resources* and *Environmental Baseline* sections of this opinion, several threats have been identified that may have or continue to lead to the decline of Hawaiian monk seals. Hawaiian monk seals are threatened by natural predation, disease outbreaks, biotoxins, and agonistic behavior by male Hawaiian monk seals (NMFS 2011d). Hawaiian monk seals, particularly pups, are also subjected to extensive predation by sharks, which appear to be a significant problem for the Hawaiian monk seals occupying French Frigate Shoals in the Northwest Hawaiian Islands (Antonelis et al. 2006). One

of the most substantial threats to Hawaiian monk seals results from dramatic declines in the survival of juveniles and appears to be related to significantly reduced body sizes in pup and juvenile animals. Several human activities are known to threaten Hawaiian monk seals: commercial and subsistence hunting, intentional harassment, competition with commercial fisheries, entanglement in fishing gear, habitat destruction on breeding beaches, pollution, and unintentional human disturbance (Kenyon 1981; Riedman 1990; Reeves et al. 1992). The revised recovery plan for Hawaiian monk seals identified food limitation, entanglements, and shark predation as crucial threats to the continued existence of this species (NMFS 2007c).

Under the LOA that will be issued for the proposed seven-year rule, assuming the Navy reaches the maximum extent of the proposed MMPA authorized take, there will be approximately 79 instances of behavioral responses that constitute ESA take in the form of harassment from SURTASS LFA sonar training and testing activities for Hawaiian monk seals. As stated in Section 6.9, the latest published estimate of the total population of Hawaiian monk seals is 1,427 (NMFS 2018e). Based on the maximum annual instances of harassment (from behavioral response) during which takes will be greatest for SURTASS LFA sonar training and testing activities (years 5-7, See Table 9), instances of take would result in only 0.91 percent of the stock being affected by SURTASS LFA sonar transmissions per year. Based on the Navy's operational history, we assume that this species will experience behavioral responses that constitute ESA take in the form of harassment from SURTASS LFA sonar at levels no higher than those proposed in the Navy's biological evaluation (Navy 2018a) for the duration of the seven-year proposed action and into the reasonably foreseeable future.

As described further in section 8.2 and 8.5, the evidence available suggests that when exposed to SURTASS LFA sonar transmissions, Hawaiian monk seals, like other pinnipeds, are not likely to be killed or experience injury, significant masking, stranding, resonance effects, or behavioral responses that might reduce the longevity or reproductive success of individuals that have been exposed. Instead, the best scientific and commercial data available suggests that SURTASS LFA sonar transmissions are likely to elicit short-term behavioral responses that are not likely to impact the fitness of the individual seals exposed. An action that is not likely to reduce the fitness of individual seals is not likely to reduce the viability of the populations those individual seals comprise (that is, we would not expect reductions in the reproduction, numbers, or distribution of those populations) and therefore, we do not expect exposure to SURTASS LFA sonar to result in substantial changes in reproduction, numbers, or distribution of these populations. By the same logic, we do not anticipate any reductions in survival rate or trajectory of recovery of the species as listed pursuant to the ESA that could be readily perceived or estimated.

The 2007 Hawaiian monk seal recovery plan defines seven recovery populations, the French Frigate Shoals, Lisianski Island, Midway Atoll, Laysan Island, Pearl and Hermes Reef, Kure Atoll, and Main Hawaiian Islands, and sets criteria, for the downlisting and delisting of this species. Both downlisting and delisting requirements include abatement of threats associated

with food limitation, debris entanglement, predation, fisheries, erosion, and disease. None of these stressors have been determined to be relevant to SURTASS LFA sonar training and testing activities with regards to this species. Downlisting criteria for Hawaiian monk seals includes the maintenance of 2,900 individuals in the Northwestern Hawaiian Islands, at least five of the six Northwestern Hawaiian Islands sub-populations with at least 100 individuals and the Main Hawaiian Island population above 500 individuals, and a population growth rate of zero or higher. To quantify for delisting, the downlisting criteria must be met for 20 consecutive years. As described previously, we conclude the temporary effects from acoustic stressors associated with Navy SURTASS LFA sonar training and testing activities will not impact the fitness of any individuals of this species or the populations to which they belong.

Based on the evidence available, including the *Environmental Baseline* and *Cumulative Effects*, stressors resulting from the Navy SURTASS LFA sonar training and testing activities that will be conducted in the action area (see section 3.6) on an annual basis for the reasonably foreseeable future (assuming there are no significant changes to the *Status of Endangered Species Act-Listed Resources* or *Environmental Baseline*), would not be expected, directly or indirectly, to appreciably reduce the likelihood of the survival of Hawaiian monk seals in the wild by reducing the reproduction, numbers, or distribution of that species.

10.1.10 Spotted Seal – Southern Distinct Population Segment

In determining whether the Navy's SURTASS LFA sonar routine training and testing activities in the action area are likely to jeopardize the survival and recovery of the Southern DPS of spotted seals, we assessed effects of the action against aggregate effects of everything in the *Environmental Baseline* that has led to the current *Status of Endangered Species Act-Listed Resources* and, those effects of future non-Federal activities that are reasonably certain to occur within the action area in the reasonably foreseeable future.

As described in the *Status of Endangered Species Act-Listed Resources* and *Environmental Baseline* sections of this opinion, several threats have been identified that may have or continue to lead to the decline of the Southern DPS of spotted seals. The Southern DPS of spotted seals have long been a target of commercial and subsistence hunting, but threats from climate change and environmental contaminants are more recent developments. Although significant direct effects from climate change are not expected, indirect effects can be important (Boily 1995; Harding et al. 2005; Grebmeier et al. 2006). These include changes in prey abundance or distribution, predation, and disease (Grebmeier et al. 2006; Boveng et al. 2009b; Comeau et al. 2009). Additionally, Southern DPS of spotted seals are still hunted for meat, fur, oil, and animal feed by coastal inhabitants of the northern Pacific rim (Krylov et al. 1964; Fedoseev 1984).

Under the LOA that will be issued for the proposed seven-year rule, assuming the Navy reaches the maximum extent of the proposed MMPA authorized take, there will be approximately three instances of behavioral responses that constitute ESA take in the form of harassment from SURTASS LFA sonar training and testing activities for Southern DPS spotted seals. As stated in Section 6.10, the Southern DPS population of spotted seal could number as many as 3,500

individuals. However for the purpose of this action, the breeding population in Liaodong Bay, which is estimated at 1,000 individuals, was used (Han et al. 2010). Based on the maximum annual instances of harassment from behavioral responses during which takes will be greatest for SURTASS LFA sonar training and testing activities (years 5-7, See Table 9), instances of take would result in only 0.05 percent of the Southern DPS of spotted seal being affected by SURTASS LFA sonar transmissions per year. Based on the Navy's operational history, we assume that this DPS will experience behavioral responses that constitute ESA take in the form of harassment from SURTASS LFA sonar at levels no higher than those proposed in the Navy's biological evaluation (Navy 2018a) for the duration of the seven-year proposed action and into the reasonably foreseeable future.

As described further in section 8.2 and 8.5, the evidence available suggests that when exposed to SURTASS LFA sonar transmissions, Southern DPS of spotted seal, like other pinnipeds, are not likely to be killed or experience injury, significant masking, stranding, resonance effects, or behavioral responses that might reduce the longevity or reproductive success of individuals that have been exposed. Instead, the best scientific and commercial data available suggests that SURTASS LFA sonar transmissions are likely to elicit short-term behavioral responses that are not likely to impact the fitness of the individual seals exposed. An action that is not likely to reduce the fitness of individual seals is not likely to reduce the viability of the populations those individual seals comprise (that is, we would not expect reductions in the reproduction, numbers, or distribution of those populations) and therefore, we do not expect exposure to SURTASS LFA sonar to result in substantial changes in reproduction, numbers, or distribution of these populations. By the same logic, we do not anticipate any reductions in survival rate or trajectory of recovery of the species as listed pursuant to the ESA that could be readily perceived or estimated. NMFS has not prepared a recovery plan for the Southern DPS of spotted seal.

Based on the evidence available, including the *Environmental Baseline* and *Cumulative Effects*, stressors resulting from the Navy SURTASS LFA sonar training and testing activities that will be conducted in the action area (see section 3.6) on an annual basis for the reasonably foreseeable future (assuming there are no significant changes to the *Status of Endangered Species Act-Listed Resources* or *Environmental Baseline*), would not be expected, directly or indirectly, to appreciably reduce the likelihood of the survival of Southern DPS of spotted seals in the wild by reducing the reproduction, numbers, or distribution of that species.

10.1.11 Steller Sea Lion – Western Distinct Population Segment

In determining whether the Navy's SURTASS LFA sonar routine training and testing activities in the action area are likely to jeopardize the survival and recovery of the Western DPS of Steller sea lions, we assessed effects of the action against the aggregate effects of everything in the *Environmental Baseline* that has led to the current *Status of Endangered Species Act-Listed Resources* and, those effects of future non-Federal activities that are reasonably certain to occur within the action area in the reasonably foreseeable future.

As described in the *Status of Endangered Species Act-Listed Resources* and *Environmental Baseline* sections of this opinion, several threats have been identified that may have or continue to lead to the decline of Western DPS of Steller sea lions including, but not limited to, harvest, competition for prey with fisheries, and contaminants. The current abundance trend for Western DPS of Steller sea lions rangewide including the action area is likely still in decline (though the decline has slowed or stopped in some portions of the range).

Under the LOA that will be issued for the proposed seven-year rule, assuming the Navy reaches the maximum extent of the proposed MMPA authorized take, there will be approximately 17 instances of Western DPS of Steller sea lion harassment (from behavioral response) from SURTASS LFA sonar training and testing activities. As stated in Section 6.11, as of 2017, the best estimate of abundance of the Western DPS of Steller sea lion in Alaska was 11,952 pups and 42,315 for non-pups (total N_{min}= 54,267) (Muto et al. 2019). In addition, the non-U.S. Western DPS of Steller sea lion is approximately 17,000 individuals (Burkanov 2017). Based on the maximum annual instances of harassment from behavioral responses during which takes will be greatest for SURTASS LFA sonar training and testing activities (years 5-7, See Table 9), instances of take would result in only 0.01 percent of the Western DPS of Steller sea lion being affected by SURTASS LFA sonar transmissions per year. Based on the Navy's operational history, we assume that this DPS will experience behavioral responses that constitute ESA take in the form of harassment from SURTASS LFA sonar at levels no higher than those proposed in the Navy's biological evaluation (Navy 2018a) for the duration of the seven-year proposed action and into the reasonably foreseeable future.

As described further in Section 8.2 and 8.5, the evidence available suggests that when exposed to SURTASS LFA sonar transmissions, Western DPS of Steller sea lions, like other pinnipeds, are not likely to be killed or experience injury, significant masking, stranding, resonance effects, or behavioral responses that might reduce the longevity or reproductive success of individuals that have been exposed. Instead, the best scientific and commercial data available suggests that SURTASS LFA sonar transmissions are likely to elicit short-term behavioral responses that are not likely to impact the fitness of the individual sea lions exposed. An action that is not likely to reduce the fitness of individual sea lions is not likely to reduce the viability of the populations those individual sea lions comprise (that is, we would not expect reductions in the reproduction, numbers, or distribution of those populations) and therefore, we do not expect exposure to SURTASS LFA sonar to result in substantial changes in reproduction, numbers, or distribution of these populations. By the same logic, we do not anticipate any reductions in survival rate or trajectory of recovery of the species as listed pursuant to the ESA that could be readily perceived or estimated.

The 2008 Steller sea lion revised recovery plan defines seven recovery sub-region populations, the Eastern Gulf of Alaska, Central Gulf of Alaska, Western Gulf of Alaska, Eastern Aleutian Islands, Central Aleutian Islands, Western Aleutian Islands, and Russia/Asia, and sets criteria, for the downlisting and delisting of this species. Downlisting criteria for Western DPS of Steller

sea lions includes that the population for the U.S. region has increased for 15 years on average, based on counts of non-pups (i.e., juveniles and adults); the trends in non-pups in at least five of the seven sub-regions are consistent with the trend observed, the population trend in any two adjacent sub-regions cannot be declining significantly. To qualify for delisting, the population for the U.S. regions for Western DPS of Steller sea lions has to increase for 30 years based on counts of non-pups (i.e., juveniles and adults); the trends in non-pups in at least five of the seven sub-regions must be stable or increasing, the population trend in any two adjacent sub-regions cannot be declining significantly, and the population trend in any sub-region cannot have declined by more than 50 percent.

Based on the evidence available, including the *Environmental Baseline* and *Cumulative Effects*, stressors resulting from the Navy SURTASS LFA sonar training and testing activities that will be conducted in the action area (see section 3.6) on an annual basis for the reasonably foreseeable future (assuming there are no significant changes to the *Status of Endangered Species Act-Listed Resources* or *Environmental Baseline*), would not be expected, directly or indirectly, to appreciably reduce the likelihood of the survival or recovery of Western DPS of Steller sea lions in the wild by reducing the reproduction, numbers, or distribution of that species.

10.1.12 Threatened and Endangered Sea Turtles Affected by Seven-Year SURTASS LOA

In determining whether the Navy's SURTASS LFA sonar training and testing activities in the action area are likely to jeopardize the survival and recovery of ESA-listed sea turtles (North Indian DPS, East Indian-West Pacific DPS, Central West Pacific DPS, and Central North Pacific DPS of green turtle; hawksbill turtle; leatherback turtle; North Indian Ocean DPS, North Pacific Ocean DPS, and Southeast Indo-Pacific Ocean DPS of loggerhead turtle; and olive ridley turtle), we assessed effects of the action against aggregate effects of everything in the *Environmental Baseline* that has led to the current *Status of Endangered Species Act-Listed Resources* and, those effects of future non-Federal activities that are reasonably certain to occur within the action area in the reasonably foreseeable future.

As described in the *Status of Endangered Species Act-Listed Resources* and *Environmental Baseline* sections of this opinion, some of the primary anthropogenic threats to ESA-listed sea turtles are fisheries interactions, climate change, and impacts to terrestrial nesting habitat. SURTASS LFA sonar (or other military sonars) has not been identified as a primary threat to ESA-listed sea turtles.

Only green sea turtles (Central North Pacific DPS, East Indian DPS, North Indian DPS, and Central West Pacific DPS), hawksbill sea turtles, leatherback sea turtles, loggerhead sea turtles (North Indian DPS, North Pacific DPS, and Southeast Indian DPS), and olive ridley sea turtles are expected to be exposed to SURTASS LFA sonar during the proposed training and testing activities. Based on the Navy's operational history, this consultation assumes that the Navy's SURTASS LFA sonar training and testing activities will continue to be used in these same action areas into the reasonably foreseeable future. This includes all sea turtle species and DPSs

considered in this opinion (Table 12). As described previously, if the Navy were to propose to operate SURTASS LFA sonar in different locations from those proposed in the rulemaking/LOA, consistent with the framework established in the proposed MMPA rule, the NMFS Permits and Conservation Division would need to issue letters of authorization that authorizes take of marine mammals in these locations. Such a change would require subsequent consultation under section 7 of the ESA.

Due to the lack of more definitive data on sea turtle population distributions in the open ocean, we were not able to estimate the percentage of a sea turtle population (or number of individuals) that could be exposed to SURTASS LFA sonar sound transmission. Instead, we relied on a habitat surrogate to determine the extent of take of sea turtles due to the operation of SURTASS LFA sonar. We determined that the likelihood of sea turtles experiencing mortality or injury (including PTS), from SURTASS LFA sonar is discountable due to the high probability for sea turtles to be detected four meters from the SURTASS LFA sonar sound source. However, beyond the 4 m zone, there is a potential for sea turtles to be exposed to sound pressure levels at or above 175 dB re: 1 μPa (rms) or 200 dB re: 1 μPa^2-sec, the threshold for behavioral and TTS harassment, respectively. If sea turtles were to be exposed to these behavioral and TTS harassment sound levels during SURTASS LFA sonar training and testing activities, it is possible for them to exhibit a behavioral response that would rise to the level of take under the ESA in the form of harassment (TTS or behavioral). Nevertheless, we anticipate sea turtles exposed to LFA sonar transmissions would not exhibit long-term behavioral responses that could impact an individual's fitness. This is mainly because we do not anticipate PTS and there is only a low probability that a sea turtle would be exposed to SURTASS LFA sonar at a distance greater than four meters and less than 44 meters (i.e, the distance at which a sea turtle could be exposed to TTS) for 60 seconds.

In addition, although sea turtles are highly migratory animals, spending time in both nearshore and offshore oceanic habitats, species such as green sea turtles (juveniles and adults) can spend a great deal of their time resting and foraging in relatively shallow nearshore waters, outside of the action area for SURTASS LFA sonar training and testing activities (Hazel et al. 2009; Blumenthal et al. 2010). For example, comparisons of stable carbon and nitrogen isotope ratios between 89 green sea turtle females and their prey items in a three-source mixing model estimated that 69 percent of the females nesting on the Ogasawara Islands off Japan mainly used neritic habitats (relatively shallow zones <200 m in depth) and only 31 percent mainly used oceanic habitats (Hatase et al. 2006). Furthermore, recent Navy density estimates of sea turtles off the coast of Hawaii show that sea turtle densities are significantly reduced in depths greater than the 100m isobath (Navy 2017d). Although it is important to note that these density calculations were biased toward green sea turtles since this species is expected to be seen most often in Hawaii. Last, the potential area that could be affected by sound levels that could result in ESA harassment compared to the habitat available to sea turtle species at any one time (see Table 17) is miniscule. Due to this, the extent of estimated take by TTS and behavioral harassment, although not directly quantified, is not expected be significant.

In all, we do not expect instances of behavioral harassment to result in fitness consequences to individual ESA-listed sea turtles. This is because we do not anticipate instances of PTS or mortality and only expect a low likelihood for TTS to occur as a result of SURTASS LFA sonar training and testing activities (See Section 8.5.4 for more details). Further, due to the low predicted numbers of sea turtles that will occur in the offshore action area for SURTASS LFA sonar training and testing activities and the small amount of habitat affected (see Table 17), there is a reduced chance for sea turtles to be exposed to SURTASS LFA sonar transmissions. Accordingly, we do not expect population level effects of sea turtles as a result of SURTASS LFA sonar training and testing activities.

Based on the evidence available, including the *Environmental Baseline* and *Cumulative Effects*, stressors resulting from the Navy SURTASS LFA sonar routine training and testing activities that will be conducted in the action area on an annual basis and for the reasonably foreseeable future (assuming there are no significant changes to the *Status of Endangered Species Act-Listed Resources* or *Environmental Baseline*), would not be expected, directly or indirectly, to appreciably reduce the likelihood of the survival or recovery of any ESA-listed species of sea turtles in the wild by reducing the reproduction, numbers, or distribution of those species.

11 CONCLUSION

After reviewing the current status of the ESA-listed species, the environmental baseline within the action area, the effects of the proposed action, any effects of interrelated and interdependent actions, and cumulative effects, it is NMFS' biological opinion that the proposed action (Navy SURTASS LFA sonar routine training and testing activities from August 2019 and into the reasonably foreseeable future, as well as NMFS' Permits and Conservation Division's issuance of a proposed seven-year MMPA rule and associated seven-year LOA on the take of marine mammals incidental to the Navy's SURTASS LFA sonar training and testing activities) is not likely to jeopardize the continued existence of the blue whale; Main Hawaiian Islands Insular DPS of false killer whale; fin whale; Western North Pacific population of gray whale; Western North Pacific DPS of humpback whale; North Pacific right whale; sei whale; sperm whale; Hawaiian monk seal; Southern DPS of spotted seal; Western DPS of Steller sea lion; North Indian DPS, East Indian-West Pacific DPS, Central West Pacific DPS, and Central North Pacific DPS of green turtle; hawksbill turtle; leatherback turtle; North Indian Ocean DPS, North Pacific Ocean DPS, and Southeast Indo-Pacific Ocean DPS of loggerhead turtle; and olive ridley turtle. We also concluded that the proposed action is not likely to destroy or adversely modify designated critical habitat for the Main Hawaiian Islands Insular DPS of false killer whale and Hawaiian monk seal.

12 INCIDENTAL TAKE STATEMENT

Section 9 of the ESA and Federal regulations pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without a special exemption. "Take" is

defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by an act which actually kills or injures fish or wildlife and may include significant habitat modification or degradation which actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including, breeding, spawning, rearing, migrating, feeding or sheltering. NMFS has not yet defined "harass" by regulation.

On December 21, 2016, NMFS issued interim guidance on the term "harass," defining it as to "create the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding, or sheltering." Under the MMPA, Level B harassment for military readiness activities, such as the activities analyzed in this consultation, is defined as "any act that disturbs or is likely to disturb a marine mammal or marine mammal stock in the wild by causing disruption of natural behavioral patterns, including, but not limited to, migration, surfacing, nursing, breeding, feeding, or sheltering, to a point where such behavioral patterns are abandoned or significantly altered." For purposes of this consultation, we relied on NMFS' interim definition of harassment to evaluate when the proposed activities are likely to harass ESA-listed sea turtle species. In addition, as stated in Section 8.5, for marine mammals, we relied on the MMPA definition of Level B harassment in the context of military readiness activities to estimate the number of instances of harassment.

Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Generally, under ESA section 7(b)(4), if NMFS concludes that a federal agency action is not likely to jeopardize the continued existence of an ESA-listed species or destroy or adversely modify critical habitat, NMFS shall issue an "incidental take statement" that specifies the impact of such taking on the species, reasonable and prudent measures necessary or appropriate to minimize such impact, and terms and conditions to implement those measures. Further, when an action will result in incidental take of ESA-listed marine mammals, section 7(b)(4) requires that such taking be authorized under the MMPA section 101(a)(5) before the Secretary can issue an ITS for ESA-listed marine mammals and that an ITS specify those measures that are necessary to comply with Section 101(a)(5) of the MMPA. ESA section 7(o)(2) provides that taking that is incidental to an otherwise lawful agency action is not considered to be prohibited taking under the ESA if that action is performed in compliance with the terms and conditions of the ITS, including those specified as necessary to comply with MMPA section 101(a)(5). Accordingly, the terms of this ITS and the exemption from Section 9 of the ESA as they relate to listed marine mammals become effective only upon the issuance of MMPA authorization (including an LOA) to take the marine mammals identified here. Absent such authorization, this ITS is inoperative for ESA-listed marine mammals.

12.1 Amount or Extent of Take

Section 7 regulations require NMFS to specify the impact, i.e., the amount or extent, of such incidental taking on the species (50 CFR §402.14(i)(1)(i)). The amount of take represents the

number of individuals that are expected to be taken by an action while the extent of take (e.g., "the extent of land or marine area that may be affected by an action") may be used if we cannot assign numerical limits for animals that could be incidentally taken during the course of an action (51 FR 19922,19953; June 3, 1986)). The amount of take resulting from the Navy's SURTASS LFA sonar training and testing activities was estimated based on the best information available.

The effects analysis in this consultation concluded that marine mammal and sea turtle species are likely to be exposed to, and may be affected by, the active LFA sonar component of the SURTASS LFA sonar training and testing activities. In some instances, we concluded that this exposure is likely to result in TTS, evasive behavior or changes in behavioral state which we would consider "harassment" for the purposes of this incidental take statement. The instances of harassment for marine mammals and sea turtles would generally represent changes from foraging, resting, milling, and other behavioral states that require lower energy expenditures to traveling, avoidance, and behavioral states that require higher energy expenditures and, therefore, would represent disruptions of the normal behavioral patterns of the animals that have been exposed. As discussed throughout this opinion, these disruptions are not expected to result in fitness consequences to the animals exposed. No marine mammals or sea turtles are likely to die or be wounded or injured as a result of their exposure to SURTASS LFA sonar.

The proposed seven-year MMPA rule does not per se authorize any take of marine mammals incidental to the Navy's operation of SURTASS LFA sonar, but establishes a requisite framework to govern the NMFS Permits and Conservation Division's issuance of an LOA for the Navy to take marine mammals incidental to their SURTASS LFA sonar training and testing activities. Under NMFS's proposed seven-year MMPA rule, any authorization of take incidental to Navy SURTASS LFA sonar is conditional on the issuance of a LOA.

The incidental take statement for the issuance of an LOA specifies an amount of take that will be authorized during the seven years of activity from August 13, 2019, to August 13, 2026. The incidental "take" of ESA-listed marine mammals for all seven years of SURTASS LFA sonar training and testing activities is shown in Table 18. This consultation considered the upper limits of potential takes of marine mammals for the duration of the MMPA rule. If the Navy were to propose to operate SURTASS LFA sonar in different locations than those stated in Section 3.6, consistent with the framework established in the proposed MMPA rule, the NMFS Permits and Conservation Division would need to issue an LOA(s) that authorizes take of marine mammals in these locations. Such a change would require reinitiation of consultation under section 7 of the ESA.

NMFS is not able to estimate the number of endangered or threatened sea turtles that might be "taken" by the proposed SURTASS LFA sonar training and testing activities because such estimates are impossible to produce with current levels of knowledge. In other words, numerical values cannot be practically obtained for these species and DPSs. Although we cannot estimate the amount of take of individual sea turtles, we can estimate the extent of habitat affected by

SURTASS LFA sonar transmissions, which is used as a proxy for the take of endangered or threatened sea turtles herein. Any anticipated take of endangered or threatened sea turtles that occurs will be in the form of harassment. Mortality and/or PTS is not reasonably expected to occur in sea turtles. The anticipated level of take of any sea turtle species would be exceeded if it is determined that a sea turtle remained within 4 m (14 ft) of the transmitting LFA sonar source for an entire 60-second signal or that a vessel strike of a sea turtle has occurred, as either of these occurrences would lead to PTS and/or mortality.

Table 18. The estimated number of instances of ESA incidental takes by harassment (TTS and behavioral) from exposure to Navy SURTASS LFA sonar during from 2019 and into the reasonably foreseeable future for SURTASS LFA sonar training and testing activities.

Species	Rangewide/DPS	Total Overall ESA incidental takes for 7-year Period
Blue whale	Rangewide	763
Fin whale	Rangewide	20,871
Humpback whale	Western North Pacific DPS	25,210
North Pacific right whale	WNP	722
Sei whale	Rangewide	25,944
Western North Pacific gray whale	WNP stock and Western DPS	3
False killer whale	Main Hawaiian Islands Insular stock and DPS	7
Sperm whale Hawaiian monk seal	Rangewide Hawaii	12,483 79
Spotted seal	Southern stock and DPS	3
Steller sea lion	Western/Asian stock, Western DPS	17
Sea Turtles[+]	[+]	*

[+]Incidental take is exempted for the following sea turtle species: Green sea turtle – Central North Pacific, Central West Pacific, East Indian-West Pacific, North Indian DPSs; Hawksbill sea turtle; Leatherback sea turtle; Loggerhead sea turtle – North Indian Ocean, North Pacific Ocean, Southeast Indo-Pacific Ocean DPSs, and Olive ridley sea turtle.

*Extent of habitat exposed to ESA harassment (TTS and behavioral) is listed in Table 17. We do not reasonably expect any instances of PTS or mortality for sea turtles. While the potential for ESA harassment (TTS and behavioral) of sea turtles exists, we are not able to estimate the number of sea turtles of each species occurring in the action area that could be harassed. Take will be exceeded if activity levels (i.e., the number of LFA sonar transmission hours) as proposed are exceeded or if the monitoring program detects that a sea turtle remained within 4 m (14 ft) of the LFA sonar for an entire LFA sonar 60-second signal, or if a vessel strike of a sea turtle occurs.

12.2 Activity Levels as an Indicator of Take

As discussed in this opinion, the estimated take of ESA-listed marine mammals from SURTASS LFA sonar is based on Navy modeling, which represents the best available means of numerically quantifying take. As the level of modeled sonar increases, the amount of take is likely to increase as well. Feasible monitoring techniques for detecting and calculating all actual take at the scale of SURTASS LFA sonar training and testing activities do not exist. We are not aware of any other feasible or available means of determining when estimated take levels may be exceeded. Therefore, we must rely on Navy modeling, and the link between sonar use and the amount of take, to determine when anticipated take levels have been exceeded. As such, we established a term and condition of this incidental take statement that requires the Navy to report to NMFS any exceedance of activity levels specified in the preceding opinion and in the final MMPA rule before the exceedance occurs if operational security considerations allow, or as soon as operational security considerations allow after the relevant activity is conducted. Exceedance of an activity level will require the Navy to reinitiate consultation.

Detection of behavioral responses of juvenile or adult sea turtles at-sea during Navy SURTASS LFA sonar training and testing activities would be extremely difficult. Most forms of behavioral responses would not be detected. Also, monitoring techniques to calculate actual take, of including detection and collection of individuals and assessment of injuries or death, is not feasible for sea turtles at the scale of SURTASS LFA sonar training and testing activities. Therefore, we must rely on predicted take associated with levels of activities and any opportunistic observations of potential behavioral responses or injured or dead juvenile or adult sea turtles during SURTASS LFA sonar training and testing activities as measurements of take and a trigger for reinitiation of consultation. In the absence of observations of unanticipated levels of behavioral responses, injury, or mortality, exceedance of an activity level will require the Navy to reinitiate consultation. Exceedances at the activity level or in other planned events must be reported to NMFS prior to carrying out or as soon as operational security considerations allow, if reporting would interrupt Navy SURTASS LFA sonar training and testing activities.

12.3 Effects of the Take

In this opinion, NMFS determined that the amount or extent of anticipated take, coupled with other effects of the proposed action, is not likely to result in jeopardy to the species or destruction or adverse modification of critical habitat.

12.4 Reasonable and Prudent Measures

The measures described below are nondiscretionary, and must be undertaken by the Navy so that they become binding conditions for the exemption in section 7(o)(2) to apply. Section 7(b)(4) of the ESA requires that when a proposed agency action is found to be consistent with section 7(a)(2) of the ESA and the proposed action may incidentally take individuals of ESA-listed species, NMFS will issue a statement that specifies the impact of any incidental taking of endangered or threatened species. To minimize such impacts, reasonable and prudent measures, and terms and conditions to implement the measures, must be provided. Only incidental take resulting from the agency actions and in compliance with the terms and conditions identified in the incidental take statement are exempt from the taking prohibition of section 9(a), pursuant to section 7(o) of the ESA.

"Reasonable and prudent measures" are nondiscretionary measures to minimize the amount or extent of incidental take (50 CFR §402.02). NMFS believes the reasonable and prudent measures described below are necessary and appropriate to minimize the impacts of incidental take on threatened and endangered species:

1. NMFS' Permits and Conservation Division shall require the Navy to implement a program to mitigate and report the potential effects of SURTASS LFA sonar transmissions on threatened or endangered species of marine mammals as specified in the final regulations for the Taking Marine Mammals Incidental to U.S. Navy Surveillance Towed Array Sensor System Low Frequency Active Sonar Training and Testing in the Central and Western North Pacific Ocean and Eastern Indian Ocean (50 CFR §218 Subpart X).
2. NMFS' Permits and Conservation Division shall require the Navy to implement a program to monitor potential interactions between SURTASS LFA sonar transmissions and threatened and endangered species of marine mammals.
3. The Navy shall implement a program to mitigate and report the potential effects of SURTASS LFA sonar transmissions on threatened or endangered species of sea turtles.
4. The Navy shall implement a program to monitor potential interactions between SURTASS LFA sonar transmissions and threatened and endangered species of sea turtles.

12.5 Terms and Conditions

To be exempt from the prohibitions of section 9 of the ESA, the Permits and Conservation Division and the Navy must comply with the following terms and conditions, which implement the Reasonable and Prudent Measures described above and outlines the mitigation, monitoring and reporting measures required by the section 7 regulations (50 CFR §402.14(i)). These terms and conditions are non-discretionary. If the Navy and the NMFS' Permits and Conservation Division fail to ensure compliance with these terms and conditions and their implementing reasonable and prudent measures, the protective coverage of section 7(o)(2) may lapse.

1. The authorization shall be valid only for the training and testing activities associated with the operation of the SURTASS LFA sonar onboard the USNS *IMPECCABLE* (T-AGOS 23), USNS *ABLE* (T-AGOS 20), USNS *EFFECTIVE* (T-AGOS 21), USNS *VICTORIOUS* (T-AGOS 19), and future SURTASS LFA sonar equipped vessels that come online to either replace or complement the Navy's current SURTASS LFA sonar-capable fleet in years 5 through 7 of the proposed action. The signals transmitted by the SURTASS LFA sonar source must be between 100 and 500 Hz with a SL for each projector no more than 215 dB re: 1 µPa (rms) at 1 m and a maximum duty cycle of 20 percent.
2. The Navy shall be required to: (a) establish shut-down criteria for the SURTASS LFA sonar whenever a marine mammal or other ESA-listed species (i.e., sea turtles) is detected within the 2,000 yd mitigation/buffer, (b) not broadcast the SURTASS LFA sonar signal at a frequency greater than 500 Hz, and (c) plan its missions to ensure take levels analyzed in this opinion are not exceeded.
3. If a marine mammal or other ESA-listed species is detected within the 2,000 yd mitigation/buffer zone, SURTASS LFA sonar transmissions shall be immediately delayed or suspended. Transmissions shall not resume earlier than 15 minutes after:
   (a) All marine mammals or other ESA-listed species have left the area of the LFA mitigation/buffer and buffer zone; and
   (b) There is not further detection of any marine mammal or other ESA-listed species within the LFA mitigation/buffer zone as determined by the visual and/or passive or active acoustic monitoring.
4. The HF/M3 sonar source described in 50 CFR §218.235 shall be ramped-up to operating levels over a period of no less than five minutes. The HF/M3 SL shall not be increased if a marine mammal or other ESA-listed species is detected during ramp-up. The HF/M3 ramp-up may continue once marine mammals or other ESA-listed species are no longer detected. The HF/M3 sonar shall be ramped-up:
   (a) At least 30 minutes prior to any SURTASS LFA sonar transmissions proposed during the training and testing activities;
   (b) Prior to any SURTASS LFA sonar calibrations or testing that are not part of regular SURTASS LFA sonar transmissions described in 50 CFR §218.230; and
   (c) Any time after the HF/M3 source has been powered-down for more than two minutes.
5. The SURTASS LFA sonar shall not be operated such that the SURTASS LFA sonar sound field exceeds 180 dB (re: 1µPa [rms]):
   (a) Within 22 km (12 nmi) from any coastline, including offshore islands; and
   (b) Within one km (0.5 nmi) seaward of the outer perimeter of any designated OBIA during the biologically important season for that particular area in accordance with 50 CFR §218.230. In addition, no more than 25 percent of the authorized amount of SURTASS LFA sonar would be used for training and testing activities within 10 nmi (18.5 km) of any single OBIA during any year unless the following condition is met:

should national security present a requirement to conduct more than 25 percent of the authorized hours of SURTAS LFA sonar within 10 nmi (18.5 km) of any single OBIA during any year, naval units would obtain permission from the appropriate designated Command authority prior to commencement of the activity. The Navy would provide NMFS with notification as soon as is practicable and include the information (e.g., sonar hours) in its annual activity reports submitted to NMFS.

(c) Within Hawaii state waters (out to 3 nmi) or in the waters of Penguin Bank (defined as water depth of 600 ft (183 m) and ensonification of Hawaii state waters will not exceed 145 dB re: 1 μPa rms.

6. The Navy shall submit classified and unclassified annual mission reports to the Director, Office of Protected Resources, NMFS, no later than 60 days after the end of each year covered by the LOA beginning on the date of effectiveness of a LOA or as specified in the appropriate LOA. This report shall include numbers and locations of threatened and endangered species sightings, and all information required by the LOA, including the results, if any, of coordination with coastal marine mammal stranding networks. The annual reports shall be submitted to the following NMFS offices: (1) Chief, Permits and Conservation Division, 1315 East-West Highway, Silver Spring, Maryland; and (2) Chief, ESA Interagency Cooperation Division, 1315 East-West Highway, Silver Spring, Maryland.
7. The Navy shall collect specific data on any apparent avoidance reactions of threatened or endangered species in response to exposure to SURTASS LFA sonar transmissions, including the distance from the LFA sonar transmission, conditions of the exposure (location coordinates, depth of the species, time of day, ocean conditions, the animal's behavior before and after the exposure, and estimates of the received levels that elicited the response). These data must be reported in the annual reports described in condition 6 (above).
8. If the Navy's monitoring program identify any threatened or endangered species that demonstrate acute effects in response to exposure to LFA sonar transmissions, such as injury or death, the Navy shall immediately initiate the source shut-down protocol for the sonar system.
9. The Navy shall carry out all mitigation, monitoring and reporting requirements contained in the letter of authorization issued under section 101(a)(5)(A) of the MMPA.
10. Systematically observe SURTASS LFA sonar training and testing activities for injured or disabled marine mammals and monitor the principal marine mammal stranding networks and other media to correlate analysis of any marine mammal strandings that could potentially be associated with SURTASS LFA sonar training and testing activities.

These reasonable and prudent measures, with their implementing terms and conditions, are designed to minimize the impact of incidental take that might otherwise result from the proposed action. If, during the source of the action, the level of incidental take specified in this incidental take statement is exceeded, NMFS's Permits and Conservation Division and the Navy must

immediately reinitiate consultation and review the reasonable and prudent measures provided. NMFS' Permits and Conservation Division and the Navy must immediately provide an explanation, in writing, of the causes of any take and discuss possible modifications to the reasonable and prudent measures with NMFS' ESA Interagency Cooperation Division.

13 CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the ESA directs Federal agencies to use their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of threatened and endangered species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on ESA-listed species or critical habitat, to help implement recovery plans or develop information (50 C.F.R. §402.02).

1. We recommend SURTASS LFA sonar environmental compliance efforts integrate more effectively with Navy fleet training and testing environmental compliance efforts, including the development and implementation of acoustic threshold metrics and criteria in modeling efforts, the adaptive management process, and literature review to ensure consistency and to explore efficiencies pertaining to ESA section 7(a)(2). For example, the Navy should consider using the more robust NAEMO model in the future for developing density estimates for SURTASS LFA sonar training and testing activities.
2. We recommend the Navy consider increasing the detection capability of the area above the HF/M3 sonar system (between the vertical line array and sea surface) and conduct field experiments to update the evaluation of the effectiveness of the HF/M3 sonar system at detecting marine mammals.
3. We recommend the Navy pursue research to determine the effectiveness of the HF/M3 active sonar system at detecting ESA-listed sea turtles and large fish, including giant manta ray, sharks, and sturgeon.
4. We recommend the Navy conduct additional field experiments and research as part of the Low Frequency Sound Scientific Research Program to update the important literature on the effects and responses of ESA-listed marine mammals, sea turtles, and fish.
5. We recommend the Navy use thermal imaging cameras, in addition to binoculars and the naked eye, for use during daytime and nighttime visual observations and test their effectiveness at detecting threatened and endangered species.
6. We recommend the Navy use broader and more comprehensive field guides such as *Marine Mammals of the World, A Comprehensive Guide to Their Identification* (Jefferson et al. 2015) and the *Encyclopedia of Marine Mammals* (B. Würsig et al. 2018) in addition to current regional field guides.
7. We recommend the Navy conduct passive acoustic monitoring, using current SURTASS receiver system or additional towed system, with expanded frequency

bandwidth (i.e., broader than 0 to 500 Hz) for all ESA-listed marine mammal species that may occur in the action area.

8. We recommend the Navy consider using the potential standards for towed array passive acoustic monitoring in the *Towed Array Passive Acoustic Operations for Bioacoustic Applications: ASA/JNCC Workshop Summary March 14-18, 2016 Scripps Institution of Oceanography, La Jolla, California, USA* (Thode 2017).
9. We recommend the Navy conduct an additional LFS SRP if new SURTASS LFA sonar equipped vessels come online in years five through seven of the proposed training and testing activities. We do note that the Navy has agreed to evaluate the feasibility of a new behavioral response study for SURTASS LFA sonar through its Living Marine Resource Program.
10. We recommend the Navy coordinate with NMFS' regional science centers or other entities on availability of data on abundance and distribution of ESA-listed sea turtles and fish in the action area in order to incorporate into density models in the future.

In order for NMFS' Office of Protected Resources Endangered Species Act Interagency Cooperation Division to be kept informed of actions minimizing or avoiding adverse effects on, or benefiting, ESA-listed species or their critical habitat, the Navy should notify the Endangered Species Act Interagency Cooperation Division of any conservation recommendations they implement in their final action.

14 REINITIATION NOTICE

This concludes formal consultation for the Navy's proposed use of SURTASS LFA sonar routine training and testing activities and NMFS' promulgation of 2019 MMPA regulations regarding the Navy's SURTASS LFA sonar training and testing activities and NMFS' subsequent issuance of a LOA pursuant to the MMPA regulations. The MMPA regulations and LOA under those regulations would allow the Navy to "take" marine mammals incidental to its employment of the SURTASS LFA sonar system for a seven-year period. As 50 C.F.R. §402.16 states, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if:

(1) The amount or extent of taking specified in the incidental take statement is exceeded.
(2) New information reveals effects of the agency action that may affect ESA-listed species or critical habitat in a manner or to an extent not previously considered.
(3) The identified action is subsequently modified in a manner that causes an effect to ESA-listed species or designated critical habitat that was not considered in this opinion.
(4) A new species is listed or critical habitat designated under the ESA that may be affected by the action.

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16 APPENDICES

Appendix A

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